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Supreme Court of the United States

OCTOBER TERM, 1974

No. 74-1555

KAISER INDUSTRIES CORPORATION, *et al., Petitioners*

v.

JONES & LAUGHLIN STEEL CORPORATION, *Respondent*

APPENDIX TO PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE THIRD CIRCUIT

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KAISER INDUSTRIES CORP., *et al.*

v.

McLOUTH STEEL CORP.

[No. 17497; decided August 2, 1968]

Before: WEICK, Chief Judge, EDWARDS and CELEBREZZE, Circuit Judges.

CELEBREZZE, Circuit Judge. Appellants filed an action in the United States District Court for the Eastern District of Michigan complaining that Appellee had infringed the Appellants' patented process for refining steel with pure oxygen. Appellee first defended by contending that a know-how agreement, for which Appellee paid $100,000 to Appellants, constituted a license to use the Appellants' process. The District Court held against the Appellee on that point, *Henry J. Kaiser Company v. McLouth Steel Corporation,* 175 F.Supp. 743 D.C. Mich. 1959), and in an interlocutory appeal was affirmed by this Court. *McLouth Steel Corporation v. Henry J. Kaiser Company,* 277 F.2d 458 (6th Cir. 1960). These rulings made it possible for the Appellee to contest the validity of the Appellants' patent at the trial on infringement[1]. The handling of the protracted trial on infringement by the District Judge was a monumental task, which he performed ably and well. After unusually long and complex litigation, involving several years of pretrial research, experimentation and discovery and over an entire calendar year of trial, the District Court concluded that the patentees were the

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1. Only in exceptional circumstances can a licensee contest the validity of the patent that he is licensed to use. *Cf. Sola Electric Co. v. Jefferson Electric Co.,* 317 U.S. 173 (1942).

inventors of a process that was not anticipated by the prior art and would not have been obvious to one skilled in the art at the time of the discovery. The Court held the patent invalid, however, for the reason that the specifications did not support the claims and the claims did not measure the invention as required by 35 U.S.C. § 112 and for the further reason that the claims covered the prior art.[1a] *Kaiser v. McLouth,* 257 F.Supp. 372 (D.C. Mich. 1966). From that judgment the Appellants have perfected the instant appeal contesting the Court's rulings covering the claims and specifications; and in addition the Appellee has contested the District Court's holdings on obviousness and inventorship.

In reaching its decision, the District Court wrote a long and comprehensive decision ruling on the issues of anticipation, obviousness, inventorship, compliance of the specifications with Section 112, and compliance of the claims with Section 112. In addition the District Court ruled that the doctrine of file wrapper estoppel applied to prevent the Appellants from claiming the advance that they now allege is the gist of their invention. Since we conclude that the claims overclaim the invention as represented to the Patent Office by the patentees and that the claims cover the prior art, we

1a. The apparent inconsistency of the District Court's holding that the invention was nonobvious and the holding that the claims cover the prior art results from the manner in which the Court decided the question of obviousness. In fact, the holdings are not necessarily inconsistent since a patentee can disclose a nonobvious invention in his specifications yet claim too broadly, covering not only what is new but also what is old in the art. *Holstensson v. V-M Corp.,* 325 F.2d 109 (6th Cir. 1963).

find it unnecessary to consider the correctness of every ruling of the District Court. On the other hand, a consideration of the factual background of this case and of the errors we find in the District Court's ruling on obviousness will aid in understanding the reasoning by which this Court has reached its decision.

Plaintiffs-Appellants in this action are the owner, the exclusive world-wide licensing firm, and the exclusive licensing agent in the United States of the patent in suit. Vereinigte Oesterreichische Eisen-Und Stahlwerke Aktiengesellschaft (hereinafter VOEST), a steel company owned by the Austrian Government, is the present owner of the patent in suit by virtue of assignment from the patentees, who at the time of the experimentation that led to the application for the patent in suit were employees of VOEST. Brassert Oxygen Technik AG. (hereinafter BOT), a Swiss corporation, was formed in the early 1950's by VOEST and several other European steel companies as the exclusive world-wide licensing agent for a pool of patent rights relating to the use of oxygen in steelmaking, which included the patent in suit after its issuance in 1957. In May of 1954 BOT and the Henry J. Kaiser Company (hereinafter Kaiser), a Nevada corporation, entered into an agreement by which Kaiser became the exclusive licensing agent for BOT in the United States and thus entitled to sue for infringement of the patent in suit when it became a part of the BOT pool of patents.

Appellee McLouth Steel Corporation (hereinafter McLouth), is a Michigan corporation having a steel plant located in Trenton, Michigan, whose operations are alleged to infringe the patent in suit.

In this action McLouth is accused of infringing Patent No. 2,800,631 (hereinafter the Suess Patent), which was issued July 23, 1957, to four Austrian steelmakers, Drs. Theodor Edward Suess, Herbert Trenkler, Hubert Hauttmann and Rudolf Rinesch on the basis of a process developed at Linz, Austria, in 1949, (hereinafter the L-D Process). Only two prior art patents are relied upon by McLouth in this appeal: The Schwarz German Patent No. 735,196 dated July 3, 1943 (hereinafter the Schwarz Patent); and the Miles Belgian Patent No. 486,316 dated March 1, 1947 (hereinafter the Miles Patent). In addition, McLouth relies upon experimentation by Dr. Robert Durrer and Dr. Heinrich Hellbruegge, (hereinafter the Gerlafingen experiment) which was conducted in Gerlafingen, Switzerland, in 1948 and the spring of 1949 and the results of which were fully disclosed to the patentees, as proving non-inventorship.

Producing steel from iron ore involves at least two processes. Iron ore, which exists in nature in the form of oxides of iron, is first processed through a blast furnace where the oxygen is removed from the iron ore. This process reduces the iron oxide to relatively pure iron, but it does not remove the other impurities present in the iron ore. In fact, the blast furnace process increases the carbon content of the resultant product, which is known as pig iron. To produce steel from the pig iron, the amounts of these impurities, carbon, silicon, phosphorous, maganese, and sulphur, must be reduced to an acceptable level without adding any significant amount of oxygen or nitrogen. Accomplishing this result is the purpose of the second process involved in steelmaking: the refining process.

The patents involved in this suit are concerned exclusively with the refining process, which involves essentially oxidizing the impurities and removing them from the molten pig iron. Carbon combines with oxygen to form carbon monoxide or carbon dioxide and is exhausted as a gas. Silicon, phosphorous, sulphur, and manganese form various oxides and are absorbed into a slag layer that is formed on top of the metal bath by the addition of lime and other materials before and during the operation. Since the various impurities react with oxygen at different rates, the problem of steelmaking is to control the refining process so that sufficient amounts of all the impurities are removed.

Various methods have been devised to accomplish this refining process. The oldest method is the acid Bessemer process, which was developed in the 1850's and involves blowing air into a molten bath of pig iron from below through tuyeres in the bottom of a converter. This process was unsatisfactory for most pig iron, however, because a basic slag for phosphorous removal could not be formed in the converter, which had an acid refractory lining. As a result, only pig iron with an already sufficiently low phosphorous content could be satisfactorily refined by this method.

The Thomas process, or basic Bessemer process, was devised during 1879 to permit the use of a basic slag capable of removing phorphorous and sulphur. This process also proved unsatisfactory: because air was blown, an excessive nitrogen content developed in the steel produced, and because the blowing was from below, insufficient iron oxide was formed in the slag for phorphorous removal, thus requiring an afterblow for adequate removal of phosphorous.

Although the electric furnace has recently been used for refining, the high cost of the operation has limited its usefulness to the making of specialty steels. Therefore, since the 1880's the principal method of refining steel has been the open hearth process. As late as 1953, approximately eighty-nine per cent of the steel produced in the United States came from open hearth furnaces, which produce steel of excellent quality. The process, however, has the disadvantage of high capital and operating costs and a relatively slow rate of production. An average open hearth heat requires eight to ten hours, while a blow in a Thomas operation requires only approximately eighteen minutes.[2]

The basic process combines the best qualities of the Thomas and the open hearth processes: it produces a steel of excellent quality in a relatively short blowing period; and it has low capital and operating costs. Since VOEST began the first commercial operation of the basic oxygen process at Linz in November, 1952, the process has had a considerable impact on the steelmaking industry. According to the Appellants, more than seventy-five per cent of all new steelmaking facilities constructed since 1954, or now in the planning stage, use the basic oxygen process. Sixteen companies in the United States have begun or planned oxygen blowing facilities, and sixty-four companies in twenty-three countries have installed, or are installing, the new process. The process has demonstrated undoubted advantages over previous methods of refining steel. Its use has resulted in substantial savings to those companies now employing the process; and its use in the future will undoubtedly result in substantial savings and improved production for the steel industry as a whole.

2. For a more comprehensive discussion of steelmaking and the history of its development see the District Court's Opinion, 257 F. Supp. at 378-9.

McLouth is admittedly using the basic oxygen process. When in 1953 McLouth decided to expand its operations, it learned of the basic oxygen process being used at Linz and sent one of its officers to Linz to observe the operations. Further information about the process was obtained from Kaiser, and in 1954 Kaiser agreed to furnish know-how, engineering knowledge, and consultation services to McLouth at a cost of $100,000. With this assistance McLouth constructed its OP-1 steelmaking shop, the design of the operation being copied from the one at Linz. Although McLouth interpreted the know-how agreement as a license to use the basic oxygen process, Kaiser brought suit for patent infringement. When the Suess Patent was finally granted, the complaint was amended to allege infringement of that patent.

In the District Court, McLouth raised virtually all of the standard defenses in a patent case from invalidity and non-infringement to patent misuse.[3] Although the District Court's judgment for McLouth was based on the Section 112 defenses and although our affirmance is based on the same defense, a discussion of the District Court's treatment of the defense of obviousness will better provide the necessary background. The primary thrust of McLouth's defense appears to be this: when properly practiced the process taught in the prior art Schwarz and Miles Patents produces the same results

3. 257 F. Supp. at 386.

in the same way as the L-D Process disclosed in the specifications of the Suess Patent. In asserting the defense McLouth evidenced some confusion as to whether this contention should be raised under the defense of anticipation or under the defense of obviousness; and McLouth's ambivalence concerning the proper defense seems to have contributed to the District Court's failure to make certain essential findings of fact on the issue of obviousness. We share some of the Appellee's perplexity concerning the proper defense,[4] but in view of the disposition made of the case find it unnecessary to resolve that issue.

Appellants contend that ". . . it lies ill in the mouth of this copyist to assert . . . invalidity . . ." But when the defense is that the advance claimed by the patentees would have been obvious to one skilled in the art, more is involved than a weighing of the equities between the parties. The question becomes one of the public policy in granting patent monopolies and of applying the constitutional and statutory standards requisite to such a grant. *Graham v. John Deere Co.*, 383 U.S. 1 (1966).

In essence McLouth contends that the Linz experiments were nothing more than the development of know-how and engineering knowledge to facilitate the establishment of the first commercial basic oxygen process. If this contention is true, the Appellants had nothing to sell but know-how, which they sold to McLouth for $100,000. To counter this contention, the Appellants contend that the patentee's new concept ". . . was the direct antithesis of the thinking then prevalent in the steelmaking art." This penchant of the patentees for creating a verbal antithesis to distinguish every patent that might serve as an interference reference has raised other problems of divining exactly what novel element the patentees claim and how that novel element might be meaningfully distinguished from the prior art. Appellants say that the Suess Patent teaches "avoidance of deep penetration", where the Schwarz and Miles Patents taught "deep penetration". But "avoidance of deep penetration" as an abstract phrase means no more to one skilled in the art than does "deep penetration". Depth of penetration can gain meaning only from the limitations placed upon it by the patents and from the knowledge that may be attributed to an ordinary worker skilled in the art.

The nature of McLouth's defense compels the Court to attempt to distinguish inventive experimentation from mere development of know-how in an art with which the Court has no familiarity. The ultimate distinction is one of law because it amounts to a determination of obviousness or non-obviousness. *A. & P. Tea Co. v. Supermarket Corp.*, 340 U.S. 147 (1950). Several basic factual inquiries are essential, however, to establish a foundation upon which the legal conclusion can be based. The scope and content of the prior art must be determined; the differences between the prior art and the claims at issue must be ascertained; and the level of ordinary skill in the pertinent art must be resolved. *Graham v. John Deere Co.*, 383 U.S. 1, 17 (1966).

4. In *Graham v. John Deere Co.*, 383 U.S. 1, 10-2 (1966), the United States Supreme Court noted the confusion that resulted from the early development of the term "invention" as a word of legal art. Although *Graham* went far towards clearing up the confusion, certain areas still remain perplexing.

In the *Graham* case the United States Supreme Court noted that secondary considerations, such as longfelt but unsolved needs, commercial success, and the like, might have some relevance on the issue of obviousness. 383 U.S. at 17-18. But the Court's further analysis of the Scoggins Patent, 383 U.S. at 26-36, shows clearly that these considerations are truly secondary and will not serve as a substitute for more direct evidence of obviousness. The difficulty we find with the District Court's conclusion of nonobviousness is that the conclusion is based entirely upon these secondary considerations.[5] We do not have the benefit of a complete determination of the difference between the prior

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5. The District Court did not extensively analyze the prior art patents in the section of the Opinion concerned with obviousness. The most extensive analysis of the prior art patents was made in the section of the Opinion concerned with the defense of anticipation, 257 F. Supp. at 387-395, where the test applied was that the disclosures of the prior patents must be so full and complete as to require *no* further experimentation. Whatever the proper test for anticipation may be, that is not the test for obviousness, where the inquiry is whether the experimentation involved was within the ingenuity of a workman having ordinary skills in the art. *Reiner v. I. Leon Co., Inc.*, 285 F.2d 501 (2d Cir. 1960). Because of the stringent test applied, the findings of the District Court in the section concerning anticipation cannot be applied to a determination of obviousness without some qualifications. The same qualifications must be applied to the findings in the section of the Opinion concerned with inventorship, 257 F. Supp. at 406-419, where the same stringent test of "*no* further experimentation" was employed. Since the District Court did not rely upon these findings in concluding that the patentees' invention was nonobvious, we consider them applicable only after a proper evaluation with the test of obviousness in mind.

art and the patent in suit or of any findings concerning the level of skill in the pertinent art.

In determining the prior art a court must consider only the art prior to the date of invention and not read into the prior art knowledge obtained from later disclosures. A foreign inventor, however, cannot establish a date of invention earlier than his first filing date in a foreign country, when that date is earlier than his first filing date in this country. 35 U.S.C. §§ 104 and 119. Patentees filed their first application for a patent on the L-D Process in Austria on January 31, 1950; so that is the earliest termination date for consideration of prior art.

Prior to 1950 not a great deal had been done commercially with the use of pure oxygen in the refining process. McLouth contends that this lapse in the steelmaking industry was due to the unavailability of a method for producing oxygen cheaply in commercial quantities. Appellants contend that the lapse was due to the lack of an operable method for refining steel with pure oxygen. In view of the conflicting evidence, the District Court found that it was unable to ascertain a date when the use of pure oxygen in commercial quantities became economically feasible but held that the unavailability of oxygen in commercial quantities would not necessarily have inhibited experimentation. 257 F.Supp. at 398. We agree with this finding of the District Court but must also note that the lack of commercial quantities of oxygen would affect the quality of the disclosures in the prior art on matters such as specific commercial operating conditions, demonstrative examples, and the like. Moreover, the commercial unavailability of oxygen would explain the absence of any prior

attempts to apply the Schwarz and Miles Patents and would thus weaken any inferences that such a lapse in the industry might raise on the issue of obviousness. Thus, the importance of more direct evidence on the issue of obviousness becomes even more apparent.

However, the District Court found three considerations dispositive of the issue of obviousness: (1) the presumption of validity of a patent; (2) the commercial success of the basic oxygen process; and (3) secondary considerations concerning prior attempts and failures at refining steel with oxygen. 257 F. Supp. at 406. Under the facts of this case, neither commercial success nor the presumption of validity will support a finding of nonobviousness. Commercial success is a relevant consideration only in a close case; it does not by itself establish the validity of a patent. *Dow Chemical Co. v. Halliburton Oil Well Cementing Co.,* 324 U.S. 320 (1945); *Great Atlantic & Pacific Tea Co. v. Supermarket Equipment Co.,* 340 U.S. 147 (1950). Thus consideration of commercial success should be put aside until some conclusion is reached on the basis of more direct evidence of obviousness or non-obviousness.

While it is well recognized that a patent will be presumed valid, 35 U.S.C. § 282, that presumption of validity is not conclusive and will be weakened when pertinent prior art was not considered by the Patent Office. *Harvey v. Levine,* 322 F.2d 481 (6th Cir. 1963); *Aluminum Company of America v. Sperry Products Inc.,* 285 F.2d 911 (6th Cir. 1960); *Tillotson Manufacturing Co. v. Textron, Inc., Homelite,* 337 F.2d 833 (6th Cir. 1964); *Felburn v. New York Central Railroad Company,* 350 F.2d 416 (6th Cir. 1965). In the instant case one of the most pertinent prior art patents, the Schwarz

Patent, was not cited as a reference by the Patent Office and, so far as the record indicates, was not considered by the Patent Office.[6] Avoidance of the Miles Patent as a covering reference was accomplished only by the addition of the claim "avoidance of material agitation of the bath by the oxygen stream." 257 F. Supp. at 404. The Schwarz Patent does not teach agitation of the bath by the oxygen stream; so that claim probably would not have distinguished the Schwarz Patent if it had been before the Patent Office. In similar circumstances this Court has considered that the presumption of validity was not a material factor in determining the validity of a patent. *Harvey v. Levine,* 322 F.2d 481 (6th Cir. 1963), *supra.*

Although the Appellants emphasize the lack of any previous litigation concerning the validity of the Suess Patent and the lack of interferences in the United States Patent Office, the licensing structure of BOT negatives any favorable inferences that might ordinarily arise from such circumstances. When the patentees first developed their process, they became concerned as how best to exploit the process worldwide. They realized that the Schwarz and Miles Patents might serve as interferences or as covering references. So, in the Appellants' words, ". . . to resolve any conflicting claims . . . the exploiting firm of BOT was formed." H. A.

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6. The only mention of the Schwarz Patent in the file wrapper is contained in the affidavits of Rinesch and Hauttmann. These affidavits were submitted only about two weeks before the issuance of the patent, and the record does not indicate what, if any, consideration the Patent Office gave to the affidavits. Such an offhand reference does not amount to Patent Office consideration of the prior art patent.

Brassert & Co., owner of the Schwarz Patent, and VOEST, along with several other European steel companies, were members of BOT from its inception. John Miles and Sons, Ltd., owner of the Miles Patent, became a member of BOT in 1952. The agreements with BOT were essentially license grant-backs: in exchange for placing in the BOT pool of patents their patents on certain uses of oxygen in steelmaking, the members obtained a license to utilize the processes of all other patents in the BOT pool. The agreements also contained provisions for the exchange of know-how and engineering knowledge. In 1954 Kaiser became a part of this arrangement.

Meanwhile, Dr. Suess applied for an Austrian patent on the L-D Process on January 31, 1950; and on January 16, 1951, fifteen days before the one year limitation contained in 35 U.S.C. § 119 would have barred his application, Dr. Suess applied for a patent on the L-D Process in the United States Patent Office. The continuation-in-part application on which a patent finally issued was not filed until 1955. Aside from the antitrust implications that the BOT arrangement might have, see *United States v. Singer Mfg. Co.*, 374 U.S. 174 (1963), since by 1952 it owned all of the most pertinent prior art patents, a reasonable inference might be made that the prior holders of those patents had no great interest in contesting the Suess Patent once it was issued.[7] Also, the most pertinent prior art

7. This inference is strengthened by the agreements between BOT and its members. For example, the agreement with Brassert concerning the Schwarz Patent concludes:

"For the duration of this agreement Brassert is engaged to enter no complaint against any patent, which is owned or controlled by BOT and which concerned the same subject of the patent transferred by this agreement and no protest against applications of such protective rights."

patents, Miles and Schwarz, were not the type for which an interference would be declared by the Patent Office. See 29 U.S.C. § 135. Hence, the prosecution in the Patent Office was not all that it could have been and would have been if the prior art patents had been owned by competitors of VOEST or had been pending or unexpired United States Patents. These considerations negative any favorable inferences that might be drawn from commercial success or a lack of previous litigation.

We also find the secondary considerations that the District Court relied upon unpersuasive. The District Court found that there had been ". . . a long-standing need for such an invention; [and] . . . many unsuccessful attempts to solve the problem." 257 F. Supp. at 406. We find no evidence in the record to support that finding.

As early as the 1850's the Bessemer process taught that steel could be refined by jetting air into a molten bath of pig iron from tuyeres located in the bottom of a converter. Another line of patents going as far back as the Robert Patent in 1888 taught surface blowing with negligible penetration, 257 F. Supp. at 403. None of these processes proved successful when oxygen was substituted for air. Mere surface blowing causes a dangerous slopping condition, 257 F. Supp. at 400, and when oxygen is blown through tuyeres located in the bottom of a converter the heat of chemical reaction at the gas outlets results in severe refractory damage

and usually blows out the bottom of the converter. 257 F. Supp. at 378.

But the apparently novel disclosure in the Schwarz Patent that gas could be blown from above with such a force that it would penetrate into a molten bath of pig iron "as a solid body" made all prior attempts to solve the problems confronted by the patentees wholly immaterial. *Graham v. John Deere Co.,* 383 U.S. 1, 36 (1966). Since the Schwarz Patent was a German patent issued in 1943, it is reasonable to assume that because of World War II, it was available to the steelmaking industry as a whole by 1946 at the earliest. The Miles Patent issued in 1947 and made a disclosure similar to Schwarz's. So any problems that might have been involved in *deep* blowing had existed for a relatively short period of time prior to the 1949 Linz experiments. See *Dempster Bros., Inc. v Buffalo Metal Container,* 352 F.2d 420 (2d Cir. 1965).

Other than the Gerlafingen experiments the record does not disclose any extensive attempts and failures to refine steel by deep blowing of oxygen between 1946 and 1949. The circumstances of this case do not allow an inference of such attempts and failures from the absence of any evidence that other companies had applied the process. As to whether other steelmakers independently arrived at the same results as VOEST, the BOT arrangement made it unnecessary for that part of the industry with experience in oxygen blowing to resolve the issue. Since that arrangement provided for the exchange of know-how and engineering knowledge, it would be impossible to separate the contribution of one from the contributions of the others to the basic oxygen process as it is practiced today. So

whether the success of that process is attributable to the disclosure of the Suess Patent is unclear.

In fact, as early as May of 1949, before the Linz experiments, VOEST entered into an agreement with several other European steel companies dividing the burden of experiments in the use of oxygen steelmaking. To VOEST fell the fortuitous obligation of continuing the Gerlafingen experiments, while the other companies were to consider other uses of oxygen in steelmaking. This agreement eliminated several potential competitors of the patentees and negates any inference of extensive experimentation and failures by others skilled in the art. Why others did not avail themselves of the knowledge contained in the Schwarz and Miles Patents is not clear, but it is clear that such evidence is not conclusive on the issue of obviousness. *Graham v. John Deere Co.,* 383 U.S. 1, 36 (1966). The failure to use a patent does not affect the validity of a patent or the persuasiveness of its teachings as a prior art reference. *Tillotson Manufacturing Co. v. Textron, Inc., Homelite,* 337 F.2d 833, 837 (6th Cir. 1964).

We also do not consider the District Court's conclusion that the Schwarz and Miles Patents are inoperable as having much relevance on the issue of obviousness.[8] This finding of the District Court was

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8. The only evidence to support the holding was the testimony of the patentees' experts, who had made no experimentations and who testified on the basis of their interpretation of deep penetration as taught by Schwarz and Miles as a penetration that damaged the refractory lining. The District Court found that Schwarz and Miles limited the penetration to a depth that would not damage the refractory lining. 257 F. Supp. at 397-8. So it is doubtfull that this evidence sup-

made in the section of the opinion concerned with the defense of anticipation and seems to have resulted from the stringent test applied in that section. Since the prior art patents did not specifically define the prescribed depths of penetration with reference to the maintenance of a fluid slag, the Court assumed that maintenance of a fluid slag was inconsistent with deep penetration as taught by Schwarz and Miles. Because a fluid slag is necessary in order to remove phosphorous, the Court concluded that the patents were inoperable. If the necessity of maintaining a fluid slag was obvious, however, so defining the depth of penetration would have been unnecessary. Therefore, to conclude from the lack of its inclusion in the definition of the depth of penetration that the characteristic itself is not comprehended within that depth of penetration begs the question when the issue is obviousness.

The application for the continuation-in-part patent was not filed until 1955, and by that time the patentees had the benefit of almost six years of experience in using the basic oxygen process plus whatever information they might have obtained through the BOT arrangement. When compared with the specifications of the parent application, the specifications of the continuation-in-part application reflect the benefit of these years of experience in the extensive discussion of the

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ports a finding of inoperability. For the same reason the Gerlafingen experiments do not prove inoperability. The District Court found that, at Gerlafingen, Dr. Durrer had not solved the refractory damage problem. 257 F. Supp. at 414. This is not a case like *Adams v. United States*, 383 U.S. 39 (1966), where an expert for the plaintiff testified *without contradiction* that he had attempted to build a battery by prior art teachings and the battery had exploded.

chemical reactions and physical phenomena that bring about the good results achieved by the basic oxygen process and in the considerable number of demonstrative examples of proper operating conditions. In comparing the disclosures of this patent with the disclosures of art prior to 1950, one must be careful to separate that part of the description containing well-known technical concepts from that part of the description that differentiates the alleged novel concept of the patentees from the prior art. So far as the District Court went in determining the differences between the disclosures of the Suess Patent and the disclosures of the prior art, we think it did an excellent job in separating the technical descriptions from the decisive distinctions. Therefore a concise statement of those findings will suffice.

Without considering the implications of the first claim of the Suess Patent,[8a] the Court found that patent's teachings to be: (1) that pure oxygen should be used; (2) that it should be blown from above onto and below the surface of the molten bath; (3) that the blowing should be carried out by means of a vertical or almost vertical lance located so that the oxygen jet impinges on the surface of the molten bath at or near the center of the upper surface; (4) that the pressure and nozzle arrangement should be such as to avoid deep

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8a. Since the invention is measured by the claims, perhaps the District Court should have first determined what the claims described as the invention, which the Court later found was not "avoidance of deep penetration". Although the approach causes some confusion, we follow it for the purpose of analyzing the District Court's conclusion on obviousness. See also footnote 1a, *supra*.

penetration of the jet into the bath; and (5) that sufficient heat for the process is produced autogenously in a limited center of chemical reaction spaced a substantial distance away from the refractory lining.

The Schwarz Patent was found to teach: (1) that oxygen enriched air or oxygen should be used; (2) that it should be blown from above into the bath "as a solid body"; (3) that the pressure and nozzle arrangement should be such that the jet penetrates deeply into the bath; and (4) that sufficient heat for the process is produced autogenously in a limited center of chemical reaction located a substantial distance from the refractory lining.[9] Schwarz contained no disclosure concerning the angle of the oxygen lance.

The Miles Patent was found to teach: (1) that an oxygen-nitrogen mixture containing 70% — 98% oxygen should be used; (2) that it should be blown from above with sufficient speed to penetrate into the bath; (3) that the blowing should be carried out by means of a lance placed at an angle of between 15 and 90 degrees to the bath surface, an angle of 30 — 75 degrees being recommended; (4) that the jet should agitate the bath; and (5) that sufficient heat for the process is produced autogenously in a limited center of chemical reaction spaced a substantial distance from the refractory lining.[10] Miles contained no specific teaching of deep penetration, but the District Court implied such a teaching from the recommendation that the gas should be jetted at a supersonic speed.

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9. Disclosure (4) is a paraphrase of the finding of the District Court at page 404 of its Opinion, rather than a paraphrase of the patent.

10. See footnote 9 concerning disclosure (5).

The use of pure oxygen is not claimed as inventive. Nor is the use of a vertical lance located so that the oxygen jet impinges on the molten bath at the center of the upper surface claimed as inventive in view of Miles' suggestion of a 90 degree angle. And the District Court found that the autogenous production of heat in a limited center of chemical reaction located a substantial distance from the refractory lining could not be claimed as an advance over the prior art. In sum, the only difference between the Suess disclosure and the prior art is the teaching of avoidance of deep penetration as opposed to deep penetration.

The difficulty arises in attempting to determine whether that distinction is merely verbal or whether it encompasses a concept that prior to 1950 would have been unobvious to a person skilled in the art. In determining the meaning of "avoidance of deep penetration," the District Court found that the only manner in which that term could be defined was by characteristics of the process. 257 F.Supp. at 400-402. Expert opinion on the percentage of bath depth that was encompassed by "avoidance of deep penetration" varied from thirty per cent to anything less than ninety per cent. 257 F. Supp. at 402. Although depth of penetration is directly related to the pressure and nozzle configuration employed and inversely related to the distance of the lance tip from the bath surface, whether certain arrangements of pressure, nozzle configuration, and bath distance would result in "avoidance of deep penetration" would depend upon the size and depth of the bath.

The characteristics of the process that would place limitations on the depth of the penetration and that

would meaningfully define the depth to one skilled in the art were found to be slopping, refractory damage, and fluidity of the slag. 257 F. Supp. at 402. The District Court found that the specifications of the Suess Patent defined "avoidance of deep penetration" as a penetration sufficient to avoid slopping but not deep enough to seriously impair refractory life or to prevent the formation of the fluid slag necessary for phosphorous removal. However, the Court found that both Schwarz and Miles similarly defined "deep penetration" as a penetration sufficient to avoid slopping but not deep enough to seriously impair refractory life. So it is apparent that the only meaningful distinction between the Suess Patent and the prior art patents is not precisely defined by the antithetical "avoidance of deep penetration" but by the teaching of the necessity of forming and maintaining an early fluid slag.

At this point the District Court should have determined what the prior art taught concerning the necessity of a fluid slag, the method of obtaining a fluid slag, and the feasibility of the suggested method. Having concisely defined the difference between the depth of penetration taught by Suess and the limitation on depth of penetration as "clearly defined" by Schwarz and Miles, the District Court failed to take this further step. Instead, the Court fell back upon the otherwise meaningless antithesis and apparently assumed, since deep penetration was not clearly limited by the teaching of formation of a fluid slag, that maintenance of a fluid slag could not be comprehended by that depth of penetration.

Persuasive evidence in the record, however, indicates that the prior art was aware of the necessity of

maintaining a fluid slag. As indicated, the purpose of the fluid slag is to remove phosphorous; and on this point the Miles Patent teaches that "the silicon and the phosphorous pass into the slag." In explaining the functioning of the slag, Miles further teaches that "the high speed jet causes a vigorous agitation and an entrainment of the slag in the body of the metal, thus assuring an intimate mixture and rapid reactions . . .[and] in each of these cases, the oxygen of the jet reacts not only with the constituent elements of the metal *but also with the slag, thus increasing the oxygen content of the latter and therefore the oxidizing* reactions in general . . . [and further] the jet actually strikes the slag at the surface of the molten metal and acts on the metal by passing through the slag and reaching the metal and/or *by renewing the slag so as to regenerate or increase its power to act on the metal.*" (Emphasis added) Miles also teaches that the speed of the jet of oxygen can be varied, which to one skilled in the art is the same as teaching that the amount of penetration can be varied, and that "[t]he course of the refining can be controlled . . . by varying the velocity of the gases . . ." These disclosures appear clearly to teach that phosphorous is removed by reactions with the slag, that the oxygen jet reacts with the slag and increases the slag's reaction capabilities, and that the course of the refining can be controlled by varying the amount of penetration of the jet. In addition, Dr. Chipman, the patentees' expert, testified that a knowledgeable person skilled in the art would know what he should do to obtain an active slag.

On the other hand, Appellants contend that persons skilled in the art prior to 1950 were so concerned with stirring the bath by the oxygen stream that they would

not have thought refining possible at a depth of penetration where a fluid slag is maintained. The recommendation of supersonic speeds in the prior art patents lends some credence to this assertion. Also, the Gerlafingen experiments show that at least one experimenter had not solved the refractory damage problem. The failures at Gerlafingen, however, are more readily explainable by the cumbersome nature of the equipment used[11] than by any "blind spot" concerning the stirring of the bath. in any event, such an isolated incident can hardly prove that persons skilled in the art in the entire steelmaking industry had a "blind spot" concerning the depth of penetration that would cause them to ignore the other teachings of Schwarz and Miles.

The District Court's conclusion of nonobviousness could have been affirmed if other evidence, whether relied upon or not, had supported that conclusion. *Cold Metal Process Co. v. McLouth Steel Corporation,* 126 F.2d 185 (6th Cir. 1942). Other evidence, however, leaves that conclusion considerably in doubt. On the other hand, if the disclosures of the Miles Patent were the only evidence on obviousness, this Court could reverse, making a finding of obviousness on the disclosures of that document. See *Shumaker v. Graboski Industries, Inc.,* 352 F.2d 837 (7th Cir. 1965); *Letcher County, Ky. v. Defoe,* 151 F.2d 987 (6th Cir. 1946). Conflicts in the evidence, however, require factual determinations which are best entrusted to the District Court in the first instance, and which the District Court did not make in this case. However, the case need not be remanded for further findings because the District Court can be affirmed on another ground.

11. The gist of the negotiations preceding the transfer of the oxygen blowing experiments from Gerlafingen to Linz was that the transfer was made because Gerlafingen did not have an oxygen plant and because other factors made experimentation cumbersome. In addition Dr. Trenkler testified that the lance used at Gerlafingen could not be raised or lowered during the process. Also Dr. Durrer testified that the experiments were moved to Linz because of the better conditions there.

Assuming that "avoidance of deep penetration" defines some meaningful concept, the claim of the Suess Patent does not describe that concept as the subject matter of the invention and does not distinguish the alleged invention from the prior art. Apparently the patentees were aware that, when it is once admitted that the oxygen jet penetrates into the bath to any not insubstantial degree, it becomes almost impossible to distinguish "deep penetration" as taught by Schwarz and Miles from "avoidance of deep penetration" as taught by the patentees. The various patent applications on the L-D Process reflect this difficulty. When confronted by an interference by the Schwarz Patent in making application for a German patent, Dr. Suess replied:

> "In contradistinction to . . . [Schwarz], in the case of the present invention the molten bath is blown with so little kinetic energy that the oxygen does not penetrate. . . ."

And later to further opposition Dr. Suess again replied:

> ". . . the oxygen is not blown into the molten bath, but rather onto the surface of the bath and reacts at the surface. . . The jet of oxygen . . . acts only on the surface. . ."

Likewise in their Australian application for a patent the patentees stated that ". . . the gas jet does not penetrate into the bath of molten metal . . . [and further] an essential characteristic of the invention is that the gas jet does not penetrate into the bath . . ." In other applications the amount of penetration was not even urged as the gist of the invention; rather the patentees contended that the good results of the L-D Process were due to the maintenance of a proper ratio between the bath surface and the bath depth.[12]

Standing alone, this evidence of statements in foreign applications for patents would not necessarily bind the patentees to any particular description of avoidance of deep penetration. The same arguments, however, were used in the prosecution of the United States applications. When confronted by interference from the Miles Patent, the patentees stated:

> "[the] . . . conditions of blast nozzle operation . . . distinguish the applicant's method from the Miles et al. method in emphasizing a much lower impingement pressure and a practically negligible penetration of the surface of the molten metal by the oxygen jet . . . [and also] it will be evident that the blast velocity at the surface of the bath will be insufficient to cause any substantial penetration of the bath by the jet."

Also in an attempt to obtain a patent after a protracted prosecution in the Patent Office, Dr. Rinesch and Dr. Hauttmann, two of the patentees, filed affidavits to distinguish the Miles and Schwarz methods of deep blowing. To support their claim that "avoidance of deep penetration" was "just the opposite of the methods disclosed in the Schwarz and Miles et al. patents. . . ." Dr. Rinesch stated that the jet did not penetrate "appreciably" into the bath and further limited the center of reaction to the "surface layer". Likewise, Dr. Hauttmann limited the reactions caused by the oxygen jet to "the surface layer of the bath".

12. This ratio theory was also the basis of the earlier Suess application, which was rejected by the United States Patent Office and finally abandoned.

On the basis of this evidence the District Court found:

> "Clearly the patentees and their attorneys defined the avoidance of deep penetration as practically no penetration at all in order to distinguish the prior art for purposes of prosecuting their own patent applications."

Having consistently and repeatedly limited "avoidance of deep penetration" to a "practically negligible" penetration or to a "surface layer" penetration or to no penetration when faced with an interference from the Schwarz and Miles Patents, both in the United States Patent Office and in foreign patent offices, the patentees now seek a broader description of that term encompassing any penetration of one half the bath depth or less.

Dr. Trenkler testified that "avoidance of deep penetration" meant a penetration of from one-third to one-half the bath depth. Dr. Hauttmann testified that the L-D Process involved a penetration of not more than one-half of the bath depth. Appellants' experts also testified concerning an "avoidance of deep penetration" that was considerably more than negligible. 257 F. Supp. at 402. We held in *Thabet Mfg. Co. v Kool Vent*

Metal Awning Corp., 226 F.2d 207 (6th Cir. 1955), that, when a patentee defines a term and the Patent Office accepts that interpretation, the Court will give the same interpretation to the term. In prosecuting their patent application, the patentees clearly limited "avoidance of deep penetration" to a "practically negligible" penetration. The Patent Office accepted that interpretation of the term; so the patentees are not now entitled to an interpretation of "avoidance of deep penetration" encompassing more than the limitation accepted by the Patent Office. *Westinghouse Electric Corp. v. Hanovia Chem. & Mfg. Co.*, 179 F.2d 293 (3rd Cir. 1949); *Doran Coffee Roasting Co. v. Wyatt Manufacturing Co.*, 267 F.2d 200 (10th Cir. 1959).

Appellants have insisted throughout this case that they regard the subject matter of the patentees' invention to be "avoidance of deep penetration". The proposition is too well settled to need citation that the claims measure the invention. Congress has provided in 35 U.S.C. § 112:

> "The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention."

The Suess Patent concluded with two claims, only one of which need be considered. Claim 1 of the Patent states:

> "1. Method of refining molten impure iron in the presence of a slag in a vessel having a refractory lining by blowing with oxygen, which comprises discharging a stream of oxygen vertically downwardly through the slag layer onto and below the surface of the bath at the central portion thereof, to an extent to avoid material agitation of the bath by the oxygen stream, the contact of the oxygen with the bath resulting in reaction of the oxygen with a portion of the iron and with the oxidizable impurities of the bath in a localized reaction zone spaced a substantial distance from the refractory lining, the reactions in said zone resulting in refining of the iron and gas evolution and in the production of high temperature in the reaction zone away from the refractory lining, said reaction producing a circulatory movement in the molten metal, which circulatory movement brings those portions of the molten metal bath which are remote from the reaction zone into the reaction zone whereby those portions are subjected to said reaction with minimum injury to the refractory lining."

No express reference to "avoidance of deep penetration" is made in the claim. Appellants attempt to incorporate the term in the claim by relating it to the phrase ". . . to an extent to avoid material agitation of the bath by the oxygen stream . . ." and to the phrase ". . . contact of the oxygen with the bath resulting in . . . a localized reaction zone spaced a substantial distance from the refractory lining . . ." Yet neither of those phrases can be interpreted as limiting the penetration of the oxygen stream to a "practically negligible" penetration. In the case of an improvement patent, the United States Supreme Court stated in *Halliburton Oil Well Cementing Co. v. Walker*, 329 U.S. 1 (1946), that a patentee cannot obtain greater coverage for his patent by failing to describe his alleged invention than by describing it as the statute commands. We find that rule just as applicable to a process patent.

In the specifications of the Suess Patent no description of the process refers to material agitation of the bath by the oxygen stream, and no description relates agitation or the avoidance of agitation to the depth of penetration of the oxygen jet. The District Court found that the phrase "material agitation" had no meaning to one skilled in the art, and we find that ruling amply supported by the evidence. Appellants contend, however, that the phrase must be given the meaning attributed to it by the patentees as reflected in the affidavits of Dr. Rinesch and Dr. Hauttmann. In so contending the Appellants urge this Court to place an unreasonable construction on the rule stated in *Kool Vent*. That case in effect held that when a patentee places a certain limitation upon a term used in his patent he cannot later expand the scope of the term by ignoring his earlier restrictive interpretation. Appellants would have us read the rule as permitting a patentee to give meaning to a meaningless term through affidavits submitted to the Patent Office and filed somewhere obscurely in the file wrapper history of the patent.

The patent law does not require a prospective inventor to search so far in attempting to determine the scope of a patent and the areas left open for inventive inquiry. Section 112 provides that it is the claims that shall *particularly point out* and *distinctly* claim the subject matter of the patentee's invention. Certainly, terms used in the claims can gain meaning from the specifications or from the knowledge attributable to one skilled in the art. But a prospective inventor is required to go no further in attempting to determine the invention claimed and the areas foreclosed to future enterprise. When read in light of the specifications,

these claims would not describe a "practically negligible" penetration to one skilled in the art. Hence, the patentees failed to describe their invention.

The only meaningful limitation placed on the depth of penetration of the oxygen stream is the phrase ". . . a localized reaction zone spaced a substantial distance from the refractory lining." The District Court found that both Schwarz and Miles placed the same limitation on depth of penetration. So if the only difference between the patentees' process and the process taught by Schwarz and Miles is the depth of penetration of the oxygen stream, the patentees have failed to distinguish their depth of penetration in any way from the depth of penetration taught by the prior art. We recently held in *Holstensson v. V-M Corporation,* 325 F.2d 109 (6th Cir. 1963), that a policy in the patent law ". . . visits total forfeiture upon a patent which attempts to extend its monopoly to something already patented." 325 F.2d at 122. That case concerned an improvement patent, but we find the rule just as applicable to the patent in suit.

In our view of this case, the Appellants ask this Court to ignore the precision of definition required of them by the statute. As the Supreme Court noted in *United Carbon Co. v. Binney Co.,* 317 U.S. 228 (1942), to allow claims "so indefinite as not to give the notice required by the statute would be in direct contravention of the public interest which Congress . . . recognized and sought to protect." In that case the Court considered a product patent where the distinction from the prior art was a matter of degree. The Court rejected terms, such as "substantially pure", "commercially uni-

form", and "comparatively small", that gave no standard for comparison or were so indefinite as to have no established meaning to one skilled in the art.

Likewise, in the instant case we are concerned with a patent that varies from the prior art only in the alleged degree of penetration of the oxygen stream. But the only term allegedly defining that difference has no established meaning. When patentees' experts were asked when agitation became material, they uniformly replied, "I don't know." As indicated earlier the specifications nowhere establish a standard for determining when agitation becomes material and nowhere relates the amount of agitation to the depth of penetration. The knowledge attributable to one skilled in the art will also not aid the patentees in reading their alleged invention into the claim. Whatever interpretation one skilled in the art might have placed on "avoidance of material agitation", it would not have been the "practically negligible" penetration that the patentees represented to the Patent Office as "avoidance of deep penetration." The District Court found that continued shallow blowing causes a turbulent slopping condition.

Although a slopping condition might appear inconsistent with what the specifications would teach one skilled in the art concerning the depth of penetration of the oxygen stream, the inconsistency arises because of the inconsistent positions that the patentees assumed before the Patent Office. If the patentees had contended for the amount of penetration before the Patent Office that they now urge upon this Court, their patent would probably not have passed muster. The inconsistency could have resulted from the rather indeterminate nature of the patentees' advance over the prior art, or it could have resulted from an attempt to get an artfully worded restatement of the prior art through the Patent Office. Under similar circumstances in the *Binney Co.* case the Supreme Court stated:

> "Whether the vagueness of the claim has its source in the language employed or in the somewhat indeterminate character of the advance claimed to have been made in the art is not material. An invention must be capable of accurate definition, and it must be accurately defined, to be patentable." 317 U.S. at 237.

We find that the patentees failed to define their alleged advance over the prior art and that in failing to properly limit their claims they attempted to extend their monopoly to something already patented. For either reason, or for both reasons, the patent must be held invalid.

Even if "avoidance of deep penetration" could be given a broader meaning than "a practically negligible penetration", another reason prevents the claims from being read so as to contain that limitation. The District Court found that the doctrine of file wrapper estoppel prevented the patentees from incorporating the limitation of "avoidance of deep penetration" into their Claim 1. If the patentees cannot limit their claim to this sole patentable advance over the prior art, the patent is invalid regardless of any other findings of the District Court. Resolution of the question requires certain factual inquiries into the file wrapper history of continuation-in-part Application No. 547,233.

In attempting to apply the doctrine of file wrapper estoppel to the facts of the instant case, two considerations must be borne in mind: (1) 35 U.S.C. § 282 specifically provides that a patent shall be presumed to be valid and the burden of proving invalidity shall rest upon the person asserting that the patent is a nullity; thus, in the present case McLouth has the burden of proving that the patent is void; and (2) the estoppel is invoked in connection with the plaintiff's attempt to satisfy that requirement of 35 U.S.C. § 112 which provides, "the specifications shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention."

The basic principle underlying file wrapper estoppel is that "a party cannot take inconsistent positions concerning the same subject matter in different transactions." 4 Walker, Patents § 234, p. 87 (Deller 2.d ed. 1965). In making its holding concerning file wrapper estoppel, the District Court relied heavily upon *Schriber-Schroth Co. v. Cleveland Trust Co.*, 311 U.S. 211 (1940). There the Court phrased the doctrine in these words:

> "But the particular invention to which the patentee has made claim in conformity to the statute is not always to be ascertained from an inspection of the specifications and claims of the patent alone. Where the patentee in the course of his application in the patent office has by amendment cancelled or surrendered claims, those which are allowed are to be read in the light of those abandoned and an abandoned claim cannot be revived and restored to the patent by reading it by construction into the claims which are allowed." 311 U.S. at 218.

Hence, the determinative question on this issue is whether the Appellants did in fact cancel, surrender, or abandon the claim of "avoidance of deep penetration by the oxygen stream" during the prosecution of Patent Application No. 547,233.

In *Schriber,* cited by this Court in *Bobertz v. General Motors Corporation,* 228 F.2d 94 (6th Cir. 1955), the Supreme Court said:

> "It is a rule of patent construction consistently observed that a claim in a patent as allowed must be read and interpreted with reference to claims that have been cancelled or rejected, and the claims allowed cannot by construction be read to cover what was thus eliminated from the patent. [Citing cases.] The patentee may not, by resort to the doctrine of equivalents, give to an allowed claim a scope which it might have had without the amendments, the cancellation of which amounts to a disclaimer. (Citing cases.)
>
> The injurious consequences to the public and to inventors and patent applicants if patentees were thus permitted to revise cancelled or rejected claims and restore them to their patents are manifest. See Leggett v. Avery, 101 U.S. 256, 259, 25 L.Ed. 865.
>
> "True, the rule is most frequently invoked when the original and cancelled claim is broader than that allowed, but the rule and the reason for it are the same if the cancelled or rejected claim be narrower. (Citing cases, Cf. Smith v. Magic City Kennel Club, Incorporated, 282 U.S. 784, 790, 51 S. Ct. 291, 75 L.Ed. 707)." 311 U.S. at 220-1.

In making this determination the only pertinent material in the file wrapper history of Application No. 547,233 would appear to be the parent patent Application No. 206,147 together with Patent Office correspondence, the present patent and answers of the Examiner concerning prior rejected claims, the patents against which Application No. 547, 233 was compared,[13] and the affidavits submitted with the final change in claims.[14]

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13. In the prosecution of Application No. 547,233 perhaps the Examiner considered some patents as prior art, which should not have been so considered. (e.g. the Cuscoleca Patent, filed on December 22, 1954). But whether the patentee could have been legally required to give up the claim surrendered is immaterial, the question in applying the doctrine of file wrapper estoppel is whether the patentee did *in fact* give up the claim. If the patentee disagreed with the Examiner, his remedy was appeal; he cannot give up the claim and then attempt to recover it through collateral infringement suits. *Schriber-Schroth Co. v. Cleveland Trust Co.,* 311 U.S. 211, 221 (1940). Therefore in determining what was abandoned in the rejected claims, all of the patents with which No. 547,233 was compared must be considered. Those patents were: (foreign patents are designated as such) Miles Patents (British and French)

Potts Patent (British)
Cuscoleca Patent
Cheswick Patent
Kalling Patent
Brassert Patent

Only the Cuscoleca Patent is included in the record on appeal. The assumed conflict with the other patents must be determined from correspondence in the file wrapper history of No. 547,233 and No. 206,147.

14. Although these affidavits might not be pertinent in determining other issues, such as whether the specifications support the claims, *Cf. Tillotson Mfg. Co.*

When making the parent Application, No. 206,147, in 1951, Dr. Suess did not emphasize avoidance of deep penetration as of any great significance in the process. Only one off-hand reference was made in the description that a certain pressure and nozzle arrangement would bring "about a sufficiently high reaction velocity without deep penetration of the gas into the molten bath." No claim referred to avoidance of deep penetration as an element of the process. After final rejection of No. 206,147, the Appellants on March 20, 1956, cancelled all prior claims and submitted two claims to place "the case in better form for consideration on appeal." In one of those claims, Claim 14, a reference was made to avoidance of "deep penetration of the oxygen jet into the molten metal."[15] This entire Application

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v. Textron, Inc., Homelite, 337 F.2d 833 (6th Cir. 1964), it seems that they would be appropriate considerations in determining exactly what elements of the prior claims were abandoned on submission of the final claims, in absence of other more direct evidence.

15. Section 120 of Title 35 of the United States Code grants the benefit of the earlier filing date of the parent patent, to a continuation-in-part patent when the invention was "disclosed in the manner provided by the first paragraph of Section 112 . . . in . . ." the earlier "application previously filed . . . by the same inventor . . ." Since the continuation-in-part application was made in 1955 and since the only claim containing any reference to the subject matter of avoidance of deep penetration was not made until 1956, apparently as an after-thought, some question might be raised whether the alleged invention of avoidance of deep penetration is entitled to the benefit of the earlier filing date. *Merry Manufacturing Company v. Burns Tool Company,* 335 F.2d 239 (5th Cir. 1964). If it was not so entitled, the claim would be barred by Dr. Suess' 1950 Austrian patent. 35 U.S.C. § 119. That issue, however, has not been raised in this case.

was abandoned before any Patent Office action was taken; so none of the Patent Office correspondence on No. 206,147 has much relevance on the issue of file wrapper estoppel.

Application No. 547,233, however, does make references to "avoiding deep penetration by the oxygen jet." That phrase is incorporated into each of Claims 1 through 4. In the Patent Office rejection of these claims the Examiner held them unpatentable over Brassert and Cheswick and Kalling. Brassert was said to disclose "the use of a blast of oxygen into the surface of the molten metal . . ." and "regulating the pressure and amount of the compressed air or blast . . ." Cheswick was said to disclose "the use of an oxygen blast upon the surface of molten steel for refining purposes," and Kalling was said to make the use of surface blowing "to prevent local attacks upon the furnace lining" old art. Claims 1 through 15 were rejected over the Miles French Patent and Cuscoleca. Miles was said to disclose surface blowing "with a pressure of 7 to 8 atmosphere." Most of the indicated conflicts relate in some manner to the penetration of the oxygen stream: (1) surface blowing implies very little, if any penetration; and (2) the depth of penetration is directly related to the pressure with which the oxygen is blown. On the other hand, the Examiner did not mention avoidance of deep penetration directly as a conflicting element.

The Appellants, in response to the rejection, cancelled Claims 1 through 10 but amended Claim 12 to include the statement "to avoid substantial penetration of the jet into said bath." Also Claim 16 was added, which included in it the statement, "the pressure and nozzle

spacing being related to avoid deep penetration of the oxygen jet into the molten metal." The remarks following the submission of these amendments make it clear that the Appellants considered avoidance of deep penetration an important part of the invention, specifically emphasizing "the very important particular of depth of penetration of the molten bath by the jet of oxygen."

The Patent Office never took action on these claims. Pursuant to a discussion with the Examiner, however, the amended Claims were cancelled, and Claims 17 and 18 submitted in their place. These new Claims, which with minor amendments became the final Claims, did not contain any direct reference to avoidance of deep penetration. Also the remarks accompanying the submission of the new Claims contained no reference to avoidance of deep penetration. The only references were contained in affidavits submitted by two of the patentees, Dr. Rinesch and Dr. Hauttmann.

We believe that sound inferences can be drawn from the Patent Office's rejections of earlier claims which contained the element of avoidance of deep penetration and its reference to the Cuscoleca Patent. Although the record is void as to the content of the discussion with the Examiner on May 1, 1957, we believe that an inference of abandonment can be drawn from the omission of "avoidance of deep penetration" from the final claims. In our opinion, if the element was as important as the affidavits imply, it would have been explicitly included in the claims; the Patentees were well aware that our patent laws require that the claims "distinctly" claim the alleged invention. The Appellants cannot regain the phrase or qualify the effect of their acquiescence through the affidavits. *Parke, Davis & Co. v. American Cyanamid Co.*, 207 F.2d 571, 574 (6th Cir. 1953). In

the face of prior rejections, the claim allowed, cannot, by construction or affidavit, be read to cover that which was specifically abandoned by the patentee so as to give the allowed claim a scope it might have had without the omission of the language.

In this case the issue of file wrapper estoppel hinges entirely upon the factual determination of abandonment or non-abandonment.[16] While the record does not indicate whether the District Court made any extensive factual inquiry into this problem, we believe the Court was correct in its view that abandonment is established if a phrase used in an abandoned or rejected claim is not used in a later accepted claim.

The determination being essentially a factual one, prior cases do not offer any clear-cut guide lines concerning what constitutes abandonment or non-abandonment. Most of the cases involved a *limitation* specifically imposed upon the claims by the Applicant and the Applicant was precluded in a later infringement suit from placing a broader interpretation on the Claims.[17] Here the process was reversed; the Applicant was refused a narrow claim and granted a broader claim. Although this difference does not affect the application of the doctrine of file wrapper estoppel, it does make the

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16. Certain assertions made by the Appellants deserve comment at this point. The argument that "avoidance of deep penetration" was included in Amended Claim 12 and added Claim 16 and that these Claims were *never rejected* is immaterial except for the factual inferences that might be drawn. The doctrine is equally applicable to claims given up informally pursuant to a discussion or conference as to claims given up after a formal rejection. *Graham v. John Deere Co.*, 383 U.S. 1, 32-3 (1966). That the claims allowed were broader than they would have been if the omitted phrase had been included is likewise immaterial. *Schriber-Schroth Co. v. Cleveland Trust Co.*, 311 U.S. 211, 221 (1940). As pointed out earlier, the accompanying affidavits cannot be utilized to recover the abandoned claim if its relinquishment was in fact required by the Examiner during the "discussion". *Parke, Davis & Co. v. American Cyanamid Co.*, 207 F. 2d 571 (6th Cir. 1953). The only disputable finding, therefore, is the factual determination of abandonment.

17. In these cases the factual determination was easier, because it is easier to prove the purpose of a positive occurrence such as an inclusion of an element than to prove the purpose of a negative occurrence such as the omission of an element. Was the omission made purposely or was it made under the assumption that an included phrase was the omitted phrase's equivalent? The difficulty of the determination is compounded when the final claim is broader than the cancelled claim. See *Graham v. John Deere Co.*, 383 U.S. 1, 32-3 (1966) (limitations were specifically spelled out in remarks accompanying the final submission); *Exhibit Supply Co. v. Ace Corp.*, 315 U.S. 126, 136-7 (1942) (claims limited to conductors embedded in table clear from prior rejected claims); *Keystone Co. v. Northwest Eng. Co.*, 294 U.S. 42, 47-9 (1935) (limitation clear from letter from applicant's solicitor); *Smith v. Magic City Kennel Club, Inc.*, 282 U.S. 784, 788-9 (1931); (limitation clear from prior rejection references); *I. T. S. Rubber Co. v. Essex Rubber Co.*, 272 U.S. 429, 439 (1926) (limitation clear from prior rejection reference); *Parke, Davis & Co. v. American Cyanamid Co.*, 207 F.2d 571, 574 (6th Cir. 1953) (limitation clear from statements of Patent Office); *Lyon, Inc. v. Clayton & Lambert Mfg. Co.*, 127 F.2d 164 (6th Cir. 1942) (facts not clear); *Valjean v. Perfection Stove Co.*, 103 F.2d 60, 61-2 (6th Cir. 1939) (limitations clear from rejection reference and statements of Patent Office); *Bishop & Babcock Mfg. Co. v. Western Auto Supply Co.*, 105 F.2d 886, 889 (6th Cir. 1939) (limitation clear from representations to Patent Office); *Firestone Tire & Rubber Co. v. United States Rubber Co.*, 79 F.2d 948, 954-5 (6th Cir. 1935) (limitation clear from rejection reference).

factual determination more difficult. In relying upon *Schriber-Schroth Co. v. Cleveland Trust Co.*, 311 U.S. 211 (1940), the District Court chose the case most directly in point factually with the instant situation.

Many of the facts in the *Schriber Co.* case are identical to the instant case. The question in *Schriber Co.* was whether the Jardine Patent for a piston contained a claim of a flexible web feature. 311 U.S. at 218. As the Applicants in the instant case, Jardine did not claim flexible webs as a feature in the claims originally filed; and while the application was pending, Jardine amended the claims to supply this omission; here the patentees filed a continuation-in-part application to supply the omissions. As in the instant case, these claims were rejected as reading upon other patents; as a result the claims were cancelled and new claims submitted that did not contain a claim for flexible webs. Also as here, the claims that were finally allowed were broader than if the omitted claim had been included. Appellants attempt to distinguish *Schriber Co.* on the grounds that in that case the limiting phrase was omitted as the result of an interference proceeding. That fact cannot be a distinguishing feature of the case, however, see *Graham v. John Deere Co.*, 383 U.S. 1, 32-3 (1966); otherwise, the doctrine of file wrapper estoppel would never apply to a patent where, as in the instant case, the only pertinent prior art consisted of foreign patents, because interference proceedings will not be declared on such patents by the Patent Office. 29 U.S.C. § 135.

The District Court concluded that *Schriber Co.* controlled the result concerning file wrapper estoppel. Judge Weick and I agree. Judge Edwards joins in the opinion in all respects except that he does not feel that the defense of file wrapper estoppel is established by the record.

Affirmed.

HENRY J. KAISER CO., *et al.*

v.

MCLOUTH STEEL CORP.

[No. 16900; decided July 6, 1966]

FREEMAN, District Judge.

This is an action for infringement of patent No. 2,800,631 involving a process of making steel by jetting high purity oxygen downwardly onto a bath of molten pig iron. The patent was issued July 23, 1957, to four Austrian steelmakers, Drs. Theodor Eduard Suess, Herbert Trenkler, Hubert Hauttmann and Rudolf Rinesch, as joint inventors, on the basis of experimentation with the use of pure oxygen in steelmaking dating back to June of 1949. At that time, all four men were employed by plaintiff Vereinigte Oesterreichische Eisen-und Stahlwerke Aktiengesellschaft (hereinafter called "VOEST") a steel company owned by the Austrian Government having its main factory at Linz, Austria. VOEST is presently owner of the patent in suit and all rights pertaining thereto, by virtue of assignment from the patentees. Other plaintiffs in this litigation are Brassert Oxygen Technik AG., (hereinafter called "BOT"), a Swiss corporation which is the exclusive world-wide licensing firm for the patent in suit; and Henry J. Kaiser Company (hereinafter called "Kaiser"), a Nevada corporation which is the exclusive licensing agent in the United States for the patent.

Defendant in this case is McLouth Steel Corporation (hereinafter called "McLouth"), a Michigan corporation having a place of business at Trenton, Michigan, where a steel plant is located, whose operations are alleged to infringe the patent in suit.

The oxygen steelmaking process at issue in this litigation has demonstrated in recent years undoubted advantages over older methods of steelmaking, including reduction of capital and operating costs, increase of production rates, and improvement [2] in quality of the steel produced. Therefore, perfection of the process has resulted in its large-scale adoption in the United States and throughout the world. Defendant McLouth has admitted that the new oxygen steelmaking process is "a revolutionary method of making high quality steel." (PX 96A; R. 1107, 1310.) Additionally, the process has been characterized by the President of Jones & Laughlin Steel Company as "the only major technological breakthrough at the ingot level in the steel industry since before the turn of the century." (PX 92-7; R. 1233-34.)

Basically, plaintiffs contend that the four patentees were joint inventors of this oxygen steelmaking process at Linz, Austria, in June of 1949, and that the process is the subject matter of the patent in suit, allegedly infringed by McLouth. Defendant denies these contentions and also asserts a defense of patent misuse.

I. BACKGROUND OF THIS LITIGATION

A brief discussion of the background of this litigation may serve to clarify the issues and also to provide a general perspective for the more detailed analysis of each issue to follow.*

[3] A. Steelmaking Prior to the Tests At Linz, Austria, in 1949

Steel is simply iron containing a very small percentage of other elements such as carbon, phosphorus, manganese, silicon and sulphur. Iron is found in nature in oxide forms, mixed with impurities. Thus the proc-

*The litigation has been unusually long and complex. After several years of pretrial research, experimentation and discovery, the case came to trial in October, 1963. Trial of the case required 150 days of court time, spread over an entire calendar year. More than 13,800 pages of testimony were taken, consisting largely of scientific evidence, much of which required the use of interpreters. A great number of exhibits were received in evidence, including large testing equipment, test pieces, and many demonstration movie films, as well as a considerable volume of documentary evidence. At the conclusion of the trial, briefs were prepared and submitted by the parties, totaling nearly 1000 printed pages. Final arguments lasted five days.

The Court expresses grateful appreciation to the parties and counsel for their consideration in providing the Court with a daily transcript of the testimony, bound regularly from time to time in convenient book form and also reproducing most of the documentary exhibits in uniform size and placing them in looseleaf binders for the Court's convenience. The testimony and documentary exhibits in such form occupy approximately an equal amount of library shelf space, totaling more than twelve feet.

ess of steelmaking involves reduction of iron oxide to pure iron and the removal of impurities to acceptable levels for the quality of steel desired. The blast furnace, an invention probably of Chinese origin and introduced in Europe in the sixteenth century, performs the function of reducing iron ore to relatively pure iron, but fails to separate other elements from the iron sufficiently to produce steel. In fact, the iron produced by the blast furnace, known as pig iron, acquires roughly four per cent carbon as a result of the blast furnace operation as residue from coke used in the operation to reduce iron oxide. (R. 210.) Therefore, further refining of the molten pig iron produced by the blast furnace is required to make steel. The purpose of such refining is to lower the carbon, silicon, phosphorus, manganese and sulphur content of the pig iron to desirable levels, preferably without adding any significant amounts of oxygen or nitrogen to the final steel as a result of the refining process. For example, excessive amounts of carbon, phosphorus and nitrogen cause the steel to be too brittle for many purposes. Too much sulphur has the same effect and also tends to cause surface defects in the steel produced. (R. 233-35.) On the other hand, steel with a too low manganese content will not roll or forge properly. (Re. 227-28). In the [4] process of refining pig iron, the elements of carbon, silicon, manganese and phosphorus combine with oxygen to form oxides which go into a slag layer on top of the metal bath or into the air in the form of carbon monoxide and carbon dioxide. Essentially, the problem of steelmaking is to control the refining process so as to remove sufficient amounts of all the impurities, although the various reactions do not necessarily occur at the same time.

The refining of pig iron into steel may be accomplished by any of several processes. The oldest of these, the Bessemer process, was developed in the 1850's and involves blowing air into a molten bath of pig iron from below through tuyeres in the bottom of a converter. The original Bessemer process, which used a so-called acid refractory lined with material containing silica, an acidic oxide, has proved unsatisfactory in several respects. In the first place, phosphorus is not removed, because the basic slag required for phosphorus removal cannot be used with an acid refractory. Thus the acid Bessemer process can only be used to refine pig iron which already contains a sufficiently low phosphorus content. The relative rarity of such pig iron places a serious restriction on the usefulness of the acid Bessemer process. Further, sulphur is not removed in the acid Bessemer process for the same reason. Additionally, the blowing of air into the bath causes an objectionable amount of nitrogen from the air to remain in the steel. Attempts to solve the nitrogen problem in the 1940's by blowing pure oxygen instead of air through the bottom [5] were unsuccessful because the greater heat of chemical reactions caused by pure oxygen immediately resulted in severe refractory damage.

The Thomas process, also known as the basic Bessemer process, was originated in 1879. This process requires the use of a basic lining, which permits the use of a basic slag capable of removing phosphorus and sulphur from the pig iron. However, the process makes steel which is unsatisfactory for many purposes because of an excessive nitrogen content in the steel produced. In the Thomas process, a so-called afterblow is required to remove phosphorus from the metal bath, since almost

no phosphorus is removed during the main blow when the removal of carbon, silicon and manganese takes place. Phosphorus removal requires iron oxide in the slag, but in the Thomas process, insufficient iron oxide forms in the slag to remove phosphorus until the time of the afterblow.

The principal method for refining pig iron into steel since the 1880's has been the open hearth process, which involves heating large quantities of pig iron in a furnace by means of fuel oil blown onto the surface of the bath. The open hearth process successfully removes objectionable amounts of carbon, silicon, phosphorus, manganese and sulphur from the pig iron without at the same time injecting excessive nitrogen or oxygen into the steel produced. In 1953, approximately 89% of the steel produced in the United States came from open hearth furnaces. (R. 5890.) Although the steel produced by the open hearth process is of excellent quality, the process has the disadvantages of high capital and operating costs as well as a relatively slow rate of production, an average heating requiring [6] eight to ten hours (R. 276-276-A) as compared to a blow of roughly eighteen minutes in a Thomas operation. (R. 246.)

Another process which has been used in the last sixty years for steelmaking is the electric furnace, which makes use of an arc between electrodes to heat the metal charge. The electric furnace process is generally not used for low carbon steel because of the high cost of this type of operation. The process has been used primarily for making specialty steels.

It should be noted that various attempts were made from the 1880's on to make steel successfully by blowing air from above onto the surface of a bath of molten pig iron, usually from tuyeres located in the converter wall above the surface of the bath. The work of Robert, Deemer and Brassert was significant in this regard (DX 61), but there is no evidence that such attempts led to any practical results in commercial steelmaking.

In 1928, the invention of the Linde-Fraenkl process of producing pure oxygen cheaply in large tonnage quantities created the possibility of the use of pure oxygen in the commercial refining of pig iron into steel. (R. 5068.) Starting in the 1930's, at least limited experimentation was carried on in Europe by men including Herman Brassert, Dr. Carl Schwarz and Dr. Robert Durrer using oxygen in the refinement of steel. (R. 5074, 5084, 5085.) Such experimentation led to the application by Schwarz in 1939 for a German patent on a new process of blowing oxygen from above a bath of molten pig iron deeply into the bath "in the manner of a solid body." (DX 61, Schwarz.) The patent was issued in 1943, but there is no evidence that Schwarz' work led to any practical results in commercial operations. (R. 5085.) In the 1940's, especially after World War II, [7] pure oxygen apparently became more readily available at low cost, and experimentation with oxygen in steelmaking increased in intensity. In 1946, a Belgian patent was issued to John Miles on a process involving blowing oxygen from above into a bath of molten pig iron, preferably at an angle between 35% to 70%, so as to agitate the bath by the oxygen jet. (DX 61, Miles.) Again, there is no evidence that Miles's work led to practical results in commercial operations (R. 5085), and in fact there is admittedly no evidence that steel with satisfactory phosphorus and sulphur

content was made commercially by anyone in the 1940's using a pure oxygen blowing process (R. 13, 484-86), despite extensive experimentation by a number of men in several countries of Europe. Such experimentation included a series of tests conducted in Gerlafingen, Switzerland, by Dr. Durrer and Dr. Heinrich Hellbruegge in 1948 and the spring of 1949, blowing pure oxygen downward into a bath of molten pig iron, using an afterblow to remove phosphorus after carbon had been removed in the main blow. (DX 61; R. 4915.) These tests produced steel satisfactory for some purposes, despite apparent refractory damage and an objectionably high phosphorus content in the steel produced. (R. 11,929.)

B. The Tests at Linz and Their Results

Drs. Suess and Trenkler, employees of plaintiff VOEST in Linz, Austria, learned of the work at Gerlafingen, and Dr. Trenkler visited Gerlafingen in May of 1949 to find out more about the tests and their degree of success. VOEST at this time was contemplating reconstruction and expansion of steelmaking facilities damaged in World War II (R. 2222), and was therefore naturally interested in using successful new methods of steelmaking which [8] would not require the high capital expenditures necessary for construction of open hearth operations.

In June of 1949, Drs. Suess, Trenkler, Hauttmann and Rinesch began their own tests at Linz using oxygen in a converter, initially following the instructions of Drs. Durrer and Hellbruegge to blow vertically from above deeply into the bath. (R. 2659-60; DX 11B). The results in terms of phosphorus removal and refractory damage were initially worse than those achieved at Gerlafingen. However, in further June tests in which the impact pressure of the oxygen jet against the bath surface was reduced by a change in nozzle and an increase in lance height, the results showed satisfactory phosphorus removal without even the need for an afterblow, and also an absence of refractory damage. (See *infra* II. C (3).) Thus a satisfactory oxygen blowing process was achieved for the first time in June, 1949. Tests continued well into 1950 on a larger scale as preparation for commercial operations, which were put into production at Linz in November of 1952. (PX 342, p. 12.) The VOEST plant at Linz was the first commercial operation using the vertical oxygen blowing process perfected in the earlier Linz tests.

According to plaintiffs, more than 75% of all new steelmaking facilities constructed since 1954, or now in the planning stage, use the Linz process. (PX 342, p. 13.) Sixteen steel companies in the United States alone have either begun or planned facilities using the oxygen blowing process. (PX 104, p. 3.)[1] [9] In other parts of the world, sixty-four companies in twenty-three countries have installed the new oxygen steelmaking process or are now doing so. (PX 104.)

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1. Acme Steel Co.
Allegheny Ludlum Steel Corp.
Armco Steel Corp.
Bethlehem Steel Co.
Colorado Fuel & Iron Corp.
Ford Motor Co.
Great Lakes Steel Corp.
Inland Steel Co.
Jones & Laughlin Steel Corp.
Kaiser Steel Corp.
McLouth Steel Corp.
Pittsburgh Steel Co.
Republic Steel Corp.
United States Steel Corp.
Wheeling Steel Corp.
Wisconsin Steel Div. of International Harvester Co.

C. The History of the U. S. Patent Application

Dr. Suess, one of the VOEST employees responsible for the successful tests at Linz, filed patent applications with the Austrian Patent Office as early as January 31, 1950. (PX 2C.) He subsequently filed patent applications in his own name in other countries throughout the world. The original U. S. patent application was filed by Dr. Suess alone on January 16, 1951. (PX 2B.)

The original U. S. application contained 12 claims, directed to a ratio of bath depth to surface area favorable to circulation as the gist of the invention. These claims were four times rejected by the Patent Office, and the original application was finally abandoned in June of 1956 by failure to file a brief with the Board of Appeals in opposition to the Patent Office rejections.

Meanwhile, litigation between Dr. Suess and VOEST in Austria and Germany over the ownership of patent rights for the Linz process had been settled in October, 1955, with the result that VOEST became the owner of Dr. Suess' rights in the United States application and also his other applications and patents throughout the world. (DX 93B, p. 68; PX 3C.)

On November 16, 1955, a continuation-in-part application was filed by Dr. Suess in the United States Patent Office, containing a more detailed specification than the original application and also 15 new claims, the first four of which were directed **[10]** to the avoidance of deep penetration of the bath by the oxygen stream as the gist of the invention. (PX 2A.) All the new claims were rejected by the Patent Office on June 14, 1956, as unpatentable over prior art.

On December 7, 1956, in response to the Patent Office rejection of claims, the first ten claims were cancelled and the remaining five claims were resubmitted along with a new claim. On June 11, 1957, the pending six claims were cancelled by the applicant without waiting for Patent Office action, and two new claims were submitted. In May of 1956, after the death of Dr. Suess on March 4, 1956, Drs. Hauttmann, Trenkler and Rinesch had requested to be and were joined as inventors in the United States applications. Two of these men, Drs. Rinesch and Hauttmann, filed affidavits with the Patent Office on June 11, 1957, in support of the two new claims filed at the same time. No amendments to the specification were made at this time. The letter accompanying the new claims and the affidavits stated: "The new claims are presented in view of information recently made available and which indicates that the instant application discloses a fundamentally different approach to the refining of pig iron or crude iron by means of substantially pure oxygen than was suggested heretofore." (PX 2A, p. 74.)

A single amendment was made on June 18, 1957, to one of the new claims following a conference with the Patent Office Examiner. The patent application was allowed on June 27, 1957, roughly six and one half years after the original application had been filed, and only 16 days after the two new claims were filed. The patent was issued July 23, 1957.

[11] D. The Patent in Suit (Suess, et al., No. 2,800,-631) (PX 1)

The general subject matter of the patent in suit is described at col. 3, lines 16 to 27 of the specification:

> "The process of the invention generally comprises refining the molten metal in a converter type or other suitable vessel with a high purity oxygen jet impinging vertically or approximately vertically on the melt surface substantially at the central portion thereof by means of a blast nozzle or other suitable jet producing means under controlled conditions, hereinafter defined, to supply to the molten metal the required amount of oxygen for completion of refining within a predetermined time, and to produce autogenous heat sufficient to insure completion of the refining and adequate temperature in the refined charge for subsequent handling."

The specification then discusses general features of the process and gives a range of operating conditions at col. 3, line 37, to col. 4, line 5:

> "According to the process of the invention, the high purity oxygen jet is blown vertically, or approximately vertically upon the central portion of the surface of a bath of the molten metal, the jet having a diameter and static pressure at the point of origin, that is, at the blast nozzle or other jet producing means, and the point of origin (blast nozzle) being spaced from the bath surface, such that direct contact of the oxygen jet and the molten metal is established and maintained throughout the refining period without deep penetration of the

> molten metal bath by the jet. In so operating, the area of jet impingement is controlled to produce a relatively confined zone of direct oxygen to molten metal contact with respect to the total surface area of the bath. It has been determined in application of the present invention to the refining of predominately molten pig iron charges by means of high purity oxygen, that the jet blown onto the surface of the molten iron, as above described, under a relatively low static pressure at the point of origin, for example, at the overhung blast nozzle, of from 5 to 25 atmospheres (about 75 to 375 pounds per square inch), preferably at about 8 to 12 atmospheres (about 115-175 pounds per square inch), with the jet diameter at the point of origin or blast nozzle being about 1 millimeter (1/25 inch) per ton of charge, and with the point of origin or blast nozzle spaced from the bath surface from at least 150 millimeters (about 6 inches) up to about [12] 2000 millimeters (about 80 inches), produces a sufficiently high reaction velocity of the oxygen with the bath constituents to insure the development of autogenous heat at a rate sufficient to provide the heat required for completion of the refining in a minimum of time, consistent with controlled temperature and control and development of other necessary and required process conditions, such as fluid slag, avoidance of over-oxidation (undue loss of iron to the slag), and avoidance of slopping. The process conducted under these conditions avoids a deep penetration of the oxygen gas into the molten bath which seriously impairs refractory life at the bottom of the refining vessel. In addi-

tion, the impingement area of the high purity oxygen on the central portion of the bath isolates the refractory walls of the refining vessel from the extremely high temperatures which are developed by the direct reaction of the oxygen and the molten metal."

The specification discusses the movement of the bath during the major part of the blow at col. 4, line 26, to col. 5, line 5:

"Although it is not intended to limit the present invention to any specific theory of action or mechanism, it is believed that application of the oxygen jet substantially vertically or approximately vertically upon the central portion of the bath surface brings about a flow in the molten metal from the center of the surface of the bath downwardly and then along the bottom of the refining vessel, and upwardly at the sides of the vessel to the surface of the bath, so that portions of the unrefined metal are continuously presented to a localized center of direct oxygen reaction with the bath metal, while reacted or oxidized portions of the bath move away from this reaction center. This apparent circulation of the molten material is facilitated by shaping of the bottom of the device in its refractory lining in a uniformly curved design, preferably hemispherical or similar shape, so as to offer the minimum of resistance to the circulation.

"Due to the very high affinity of oxygen for iron, initial contact of the high purity oxygen jet with the molten metal bath causes a rapid combination of oxygen and iron to form FeO in the confined

central reaction zone. This is demonstrated by ignition of the oxygen and the propagation of a visible flame within the first minute of blowing. [13] This reaction, together with oxidation of impurity elements, such as silicon and manganese, develops extremely high temperatures in the zone of direct oxygen contact with the molten metal which approach the boiling point of iron, as demonstrated by the evolution of a fume containing iron oxide and manganese oxide. A portion of the iron oxide goes to the slag with the other oxidized elements and a portion diffuses into the bath under the influence of the bath circulation, so that within the first three minutes of the blowing vigorous carbon combustion is initiated due to the high temperatures developed by these reactions. The ensuing reaction of carbon with the FeO and directly with the oxygen gas in the confined direct oxidation zone causes rapid formation of carbon monoxide and the formation of this CO causes a strong boil or agitation of the bath, which augments the bath circulation to continuously present unrefined metal to the oxygen gas reaction zone and to create a slag-metal emulsion. The oxygen jet thus contacts the emulsion of bath and slag components which presents a larger reaction surface and causes the refining reactions to progress rapidly although the oxygen jet does not penetrate deeply into the molten metal bath and is confined to an impingement area at the central portion of the bath surface. This vigorous boiling action is opposed by the pressure of the oxygen jet only in the area of impingement, and outside of this area it represents primarily endo-

thermic reduction of FeO by carbon to form the evolved carbon monoxide, which reaction thus effectively encompasses the zone of direct oxygen reaction at which the highest temperatures prevail affording a maximum measure of protection to the refractory lining of the refining vessel."

The specification also teaches that an early fluid slag is obtained which promotes satisfactory removal of phosphorus and other impurities. Specifically, the patent states at col. 5, lines 60 to 72; col. 6, lines 5 to 25:

"As above mentioned, it is a characteristic of the process of the invention that in the confined zone of direct oxygen reaction at the surface of the molten metal bath, the oxidation products of the impurities in the pig iron, such as silicon and manganese, as well as the oxidized iron form an early fluid slag which is always very rich in oxides, that is, highly oxidizing. With the formation of the slag-metal emulsion, the iron oxide reacts with the [14] carbon present in the bath, primarily outside of the direct oxygen-metal reaction zone, and since such slag-metal reactions are endothermic, the molten bath is maintained cooler in the vicinity of the walls of the refining vessel or converter. * * *

"This formation of an early highly oxidizing fluid slag is of particular value in basic refining when the process is applied to pig iron of analyses used in ordinary open-hearth practice, which would not be amenable to refining by either the acid Bessemer process due to the phosphorus content, or the basic Thomas process due to the lack of sufficient

phosphorus. With the rapid heating of the slag cover and metal bath, the proper amounts of lime or lime supplying substance, such as limestone, may be added at the beginning of the blow and during the blow to insure formation and maintenance of a slag of sufficient basicity. Thus, the early fluid, basic and highly oxidizing slag formed provides an accelerated rate of phosphorus and sulfur removal from the bath, leaving the finished steel very low in both elements. With normal open-hearth pig irons having phosphorus contents ranging from about 0.1-0.35%, and even higher, e.g., 0.85% P, and with correct lime additions, final phosphorus contents not higher than about 0.025% and as low as 0.010% are obtained by the time the carbon end point is reached with only a single slagging operation."

With reference to conditions prevailing near the end of the blow, the specification states at col. 6, lines 62 to 74:

"The vigorous boil, above mentioned, continues up to the carbon end point, and together with the induced circulation of the bath metal toward and away from the central zone of direct oxygen reaction, effectively counteracts any tendency to overoxidation of the bath. When the flame dies and carbon combustion is completed, the bath becomes relatively quiet and intimate contact between slag and metal bath ceases. The turbulence of the bath and slag due to the oxygen stream impinging from directly above is insufficient to cause continuance of oxygen-metal reactions. As a result, steels blown by the process of the invention do not

suffer from the deteriorating effects of high oxygen (FeO) contents."

The specification then gives specific details of an [15] exemplary commercial practice of the process, admittedly (Defendant's main brief, pp. 156, 170) based on experience at the VOEST plant in Linz, Austria, at col. 8, line 72, to col. 9, line 24:

"In actual practice, based on experience in operation of 30 ton converters, oxygen feed rates may be maintained such that depending upon pig iron analysis, amount of scrap addition and desired finished steel analysis, the refining to usual carbon end points on the order of 0.05% C is completed in from about 15 to about 30 minutes, preferably 18 to 22 minutes. Flow rates of from about 4000 to 8000 cubic meters of oxygen per hour are representative of the oxygen input under these conditions.

"In such exemplary commercial practice with 30 ton converters charged to 35 to 36 tons, oxygen pressures at the blast nozzle of about 8 to 10 atmospheres and oxygen jet or blast nozzle diameters of from 27.5 to 35 millimeters (1.1 to 1.4 inches) with nozzle spacings varying from 25 to 50 inches (about 650 to 1250 millimeters have been used, the preferred spacing being from 30 to 40 inches (about 750 to 1000 millimeters). In general, it may be stated that as the oxygen pressure and nozzle diameter are increased, the nozzle spacing is also increased, for example, as the capacity of the refining vessel and total charge is increased. Under these conditions, deep penetration of the molten metal bath is avoided, while the necessary displacement of the slag cover to maintain direct oxygen to molten metal contact is insured. However, in the unusual circumstances of an abnormally stiff slag cover, the blow may be initiated using mechanical means for penetrating the slag cover to establish oxygen to metal contact."

The specification continues with typical illustrations in col. 9 of the chemical composition of steels produced from various types of pig iron according to the process of the specification; also in col. 10 with "a detailed description of a typical operation of the process."

The patent concludes with two claims reading as follows [16] at col. 12, lines 10 to 33:

"1. Method of refining molten impure iron in the presence of a slag in a vessel having a refractory lining by blowing with oxygen, which comprises discharging a stream of oxygen vertically downwardly through the slag layer onto and below the surface of the bath at the central portion thereof, to an extent to avoid material agitation of the bath by the oxygen stream, the contact of the oxygen with the bath resulting in reaction of the oxygen with a portion of the iron and with the oxidizable impurities of the bath in a localized reaction zone spaced a substantial distance from the refractory lining, the reactions in said zone resulting in refining of the iron and gas evolution and in the production of high temperature in the reaction zone away from the refractory lining, said reaction producing a circulatory movement in the molten metal, which circulatory movement brings those portions of the

molten metal bath which are remote from the reaction zone into the reaction zone whereby those portions are subjected to said reaction with minimum injury to the refractory lining.

"2. The gaseous oxygen process set forth in claim 1 in which the oxygen is blown into said vessel under pressure in a range between five and about twenty-five atmospheres above normal atmospheric pressure."

E. The Licensing Structure of the Patent in Suit

In the early 1950's, VOEST and several other European steel companies were concerned with the use of oxygen in steelmaking and held or sought patents on various inventions relating thereto. According to plaintiffs:

"In order to resolve any conflicting claims which might have arisen as between VOEST and OAM, on the one hand, and the Brassert group, on the other hand, and in order to achieve the best and widest possible utilization of the various inventions relating to this new process throughout the world, the exploiting firm of BOT was formed."

(Plaintiffs' main brief, p. 446.)

On May 9, 1952, VOEST and Oesterreichisch-Alpine Montagesellschaft (OAM) [17] another Austrian steel company, entered into an agreement with BOT under which BOT was to have the exclusive right to exploit commercially the various inventions owned by the parties. (PX 4B.) Thus BOT obtained the right to exploit any patents VOEST might acquire on the oxygen blowing process developed at Linz in 1949. BOT also acquired exclusive licensing rights in the Schwarz, Miles and Mannesmann patents in 1952. (PX 9B, 9I and 9E.) In effect, BOT became the exclusive licensing agent all over the world for a so-called pool of patent rights relating to the use of oxygen in steelmaking.

On May 20, 1954, BOT and Kaiser entered into an agreement by which Kaiser became, in effect, the exclusive licensing agent for BOT in the United States, with the right to sue for patent infringement. (PX 5B.) Pursuant to this agreement, Kaiser has since given package license agreements to a number of steelmakers in this country. (PX 7B, 7C, 7D, 7E, 7K, 7M, 92-3.)

Thus, when the patent in suit was granted to VOEST in 1957, BOT and therefore Kaiser acquired the exclusive right to grant licenses under the patent in the United States, and to sue for infringement as in the instant case.

F. The History of Defendant's Operations

In 1953, defendant McLouth desired to expand its steelmaking facilities and was, therefore, receptive to new methods which might produce steel of the desired high quality at lower cost than open hearth operations. McLouth learned of the new process being used at Linz, and therefore sent one of its officers, Mr. Lindberg, to Linz to observe the new process. McLouth also got further information about the Linz process from Kaiser, [18] and on November 12, 1954, McLouth and Kaiser entered into an agreement for Kaiser to give know-how engineering knowledge and consultation services concerning the process to McLouth at a cost of $100,000. (PX 37K.) As a result, McLouth, without further ex-

perimentation of its own (R. 3507), constructed its OP-1 steelmaking shop consisting of three vessels or converters, the design of the operation being copied from the one at Linz. (R. 1283-88, 3513-16, 3525-29, 3540-41, 3573-80, 3447-51, 3490-91, 3507-08.) The OP-1 shop commenced commercial operations on December 19, 1954. In 1955, Dr. Rinesch, later a patentee of the patent in suit, visited the McLouth operation at Trenton and gave constructive advice as to the workings of the operation.

McLouth's decision "to integrate the Austrian process into its steelmaking operations" (PX 98D) resulted in substantial savings and improvements in production. In the OP-1 operation, capital costs of construction were estimated to be $10.00 per annual ton (R. 3458-63), as compared with capital costs of $30.00 to $45.00 per annual ton for an open hearth shop in 1953 (R. 3459), and operating cost savings on the OP-1 shop were about $3.00 per ton. (PX 98D.) Further, Mr. Lyle J. Johnson, McLouth's Vice-President of Engineering, testified that in 1953 the average production per hour in the OP-1 shop was 60 to 65 tons (R. 3468-69), as compared with an average production of 21 to 25 tons per hour in an open hearth operation. (R. 3467-68.) McLouth admits that, by the oxygen process, steel is made "in one-fourth the usual open hearth time." (PX 98C.)

McLouth interpreted the know-how agreement with Kaiser as a license to use the Linz process. However, Kaiser interpreted the agreement as giving McLouth merely an option to take [19] a license, and therefore eventually brought suit against McLouth for patent infringement on July 19, 1957, four days before the patent in suit was issued. On August 29, 1958, the complaint was amended to allege infringement of the patent in suit.

McLouth continued to manufacture steel successfully in the OP-1 shop, and also expanded its operations with the construction of two vessels in another shop, known as OP-2, in 1958, and adding a third vessel to the OP-2 shop in 1960.

The issue whether the know-how agreement of November, 1954, constituted a license agreement or merely an option to take a license was raised by cross motions for summary judgment, resolved by this Court in favor of Kaiser. 175 F. Supp. 743 (D.C. Mich. 1959.) The Court's holding was affirmed on an interlocutory appeal by an opinion of the Sixth Circuit Court of Appeals, dated March 28, 1960 (277 F. 2d 458). The appellate court's affirmance that the November, 1954, agreement did not give McLouth a license under the patent in suit set the stage for a trial on infringement of the Suess, et al. patent. Naturally, the interlocutory appeal necessitated some delay in bringing the suit for infringement to trial.

G. The Issues in This Case

McLouth has raised the standard defenses in a patent case of invalidity and noninfringement. More specifically, with regard to validity, McLouth has contended that the patent in suit is anticipated by prior art, in particular, the Schwarz and Miles patents; also that the process of the patent was obvious to a person skilled in the art at the time the invention was made;

and, further, that plaintiffs did not themselves invent [20] the process, having learned the process from Dr. Durrer and Dr. Hellbruegge of Gerlafingen, Switzerland. McLouth further contends that neither the specification nor claims of the patent comply with the requirements of 35 U.S.C. § 112 relating to definiteness. Defendant denies infringing the process as stated in the claims of the patent, although it does not contest the allegation that it is using the process disclosed by the specification.[2] The basis for this position is McLouth's contention that the claims are not supported by the specification.

Additionally, McLouth asserts that the patent is unenforceable because of an alleged antitrust violation and consequent patent misuse arising out of the licensing structure and practices of the so-called patent pool controlled by plaintiff BOT. In essence, defendant contends

2. Defendant admits that the process disclosed in the specification of the Suess patent in suit is the same as the process in use at the VOEST plant in Linz, Austria. (Defendant's main brief, pp. 156, 170; reply brief, pp. 12-13.) Defendant further admits that the Linz process is essentially the same as the process in use at the McLouth plant in Trenton, Michigan. (See R. 126; PX 98D.) For example, on final argument, counsel for defendant stated: "We do not contest that basically, fundamentally, the Linz process, as practiced, and the McLouth process — and I may add every other oxygen blowing process of which we have any knowledge — follows the same general method." (R. 13,487; see also R. 13,819.) and in its reply brief, defendant stated: "McLouth has never contested the fact that all oxygen blowing of a practical or commercial nature — and the 'exemplary commercial practice' of the patent is understood to be the Linz practice—is basically similar." (pp. 12-13.)

that the accumulation of a large number of patents in the hands of plaintiffs, Kaiser in the United States, and BOT in Europe and the rest of the world, partly as the result of grant-back provisions in licenses by plaintiffs, constitutes an antitrust violation.

[21] **II. THE QUESTION OF VALIDITY**

With respect to validity, it must first be noted that according to 35 U.S.C. § 282: "A patent shall be presumed valid. . . . The burden of establishing invalidity of a patent or any claim thereof shall rest on the party asserting it." Thus the burden of proof is upon McLouth in this case to establish the invalidity of the Suess patent in suit No. 2,800,631. In this connection, the Sixth Circuit Court of Appeals has commented on the weight of such a burden as follows: " . . . one otherwise an infringer who assails the validity of a patent fair upon its face bears a heavy burden of persuasion, and fails unless his evidence has more than a dubious preponderance." *Williams Mfg. Co. v. United Shoe Mach. Corp.*, 121 F. 2d 273, 277 (CA 6, 1941), quoting from *Radio Corporation of America v. Radio Engineering Laboratories, Inc.*, 293 U. S. 1, 8 (1934).

A. Anticipation

35 U.S.C. § 102 provides in pertinent part:

"A person shall be entitled to a patent unless—

(a) the invention was . . . patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent, or

(b) the invention was patented or described in a printed publication in this or a foreign

> country . . . more than one year prior to the date of the application for patent in the United States, . . ."

According to the pretrial order in this case, McLouth relies on three foreign patents as anticipation of the patent in suit or as showing the state of the art: the Schwarz German patent No. 735,196 dated July 3, 1943; the Miles Belgian patent No. 468,316 dated March 1, 1947; and the Potts British patent No. 623,881 dated May 24, 1949. However, in the opening statement and also [22] in the final briefs and arguments, McLouth relied only on the Schwarz and Miles patents as pertinent prior art, ignoring the Potts patent almost entirely. (R. 143-44; defendant's main brief, p. 212; reply brief, p. 27). For example, when asked by the court on final arguments: "Do you concede that the Schwarz and Miles patent would be the most pertinent prior art?", counsel for defendant replied: "Certainly the most pertinent patents, yes, your Honor, very much. They are the ones on which we primarily rely. There is a lot of other prior art, to some of which peripheral attention was given and which is interesting from one point or another; but these are the two patents upon which so far as the patented art is concerned McLouth relies." (R. 13,707.) Therefore, the first issue before the court on validity is primarily whether the patent in suit was anticipated by the Schwarz or the Miles patent.

With regard to what must be proven to establish anticipation by prior art as a defense under § 102, the law is clear. Initially, it must be noted that further statutory language in § 103 makes clear that an invention must be "identically disclosed or described" in a

prior art reference for the defense of anticipation to arise under § 102. Further: "In order to anticipate an invention, it is necessary that all of the elements of the invention or their equivalents be found in one single description or structure, where they do substantially the same work in substantially the same way." *Aluminum Co. of America v. Sperry Products, Inc.,* 285 F. 2d 911, 917 (CA 6, 1960). Even more significantly in this particular case: " 'A foreign patent is to be measured as anticipatory, not by what might have been [23] made out of it, but by what is clearly and definitely expressed in it. An American patent is not anticipated by a prior foreign patent, unless the latter exhibits the invention in such full, clear, and exact terms as to enable any person skilled in the art to practice it without the necessity of making experiments.' " *Aluminum Co. of America v. Sperry Products, Inc., supra,* at 922. Accord, *Allied Wheel Products v. Rude,* 206 F. 2d 752, 759 (CA 6, 1953).

Thus the issue of anticipation before the court, precisely stated, is whether McLouth has carried its heavy burden of showing that either of the Schwarz or Miles foreign patents alone identically disclosed the invention of the patent in suit in such full, clear and exact terms as to enable persons skilled in the art to practice the invention without making any further experiments.

(1) THE SCHWARZ PATENT

The Schwarz German patent (DX 61, Schwarz) teaches and claims a process of refining pig iron into steel by directing a jet of oxygen-enriched air or pure oxygen "onto the surface of the bath with such a high kinetic energy that it is capable of penetrating in the manner of a solid body deep into the bath by the use of

extremely high velocities lying preferably above the speed of sound." (DX 61, Schwarz, p. 2.) The teachings of the patent are stated in general language, and the patent does not teach specific operating conditions, such as an acceptable range of oxygen blowing pressures, flow rates, lance heights, bath depths and widths or nozzle diameters. Neither does the patent specify whether the oxygen jet is to be directed vertically downward against the bath or at an angle less than a right angle. [24] No exemplary conditions are given.

According to Dr. John Chipman, a professor emeritus of metallurgy and former head of the department of metallurgy at Massachusetts Institute of Technology, who testified for plaintiffs, the Schwarz patent does not teach a practical operating process. (R. 1019.) Defendant McLouth argues to the contrary, relying on testimony of Dr. Richard A. Flinn, a professor of metallurgical engineering at the University of Michigan, who testified for defendant. However, Dr. Flinn admitted that the Schwarz patent, unlike the patent in suit, does not teach specific operating conditions. (R. 8158-60, 8184-88.) Dr. Flinn also testified that the Suess patent in suit does not teach a practical operating process, except for the exemplary condition, because insufficient directions are given in the specification as to the proper operating conditions for heats of larger or smaller size than the 35 ton exemplary heat. (R. 7885.) Clearly, if Dr. Flinn thought that the patent in suit was too indefinite, although it contains far more specific and detailed information about operating conditions than the Schwarz patent, he could not have seriously contended that the Schwarz patent was sufficiently definite to teach

a practical operating process or to anticipate the patent in suit.

According to Dr. Durrer, a pioneer experimenter with oxygen in steelmaking, who testified at the trial, Schwarz' work never led to any practical results for commercial steelmaking. (R. 5085.) There is no evidence in the record to the contrary. Defendant relies on the fact that the Mannesmann Company in Germany took a license under the Schwarz patent in 1952, but there is no evidence that Mannesmann ever made satisfactory steel on the basis of Schwarz' teachings. Dr. Durrer [25] also testified that the Schwarz patent contained his own ideas (R. 5101; PX 301-A), yet Dr. Durrer himself required further experimentation with oxygen blowing in Gerlafingen, Switzerland in 1948 and 1949, and even with such experimentation, he did not make steel comparable to that made in Linz by the patentees starting in June of 1949. (See *infra,* II, c. (3).) The patentees tried to follow the teachings of Schwarz and Durrer in a series of tests starting June 17, 1949, but failed to get good results, requiring further experiment in a series of tests starting June 25, 1949, to get satisfactory phosphorus removal without refractory damage. (See *infra,* II, c. (3).) In this connection, the recent statement of the United States Supreme Court in *United States v. Adams,* 383 U. S. 39, 50 (1966), that an inoperable prior art reference does not negative novelty, is applicable.

There is also considerable evidence in the record that the teachings of the Schwarz patent cannot, in fact, lead to good results in steelmaking because the early fluid slag required for satisfactory phosphorus

removal according to the specification of the Suess patent in suit is not achieved with deep penetration of the bath by the jet, as taught by Schwarz. As Dr. John Elliott, a professor of metallurgy at the Massachusetts Institute of Technology, a witness for plaintiffs, testified at R. 6170:

"Q. And what effect does the deep penetration of the oxygen jet have on the slag that prevents this adequate control of phosphorus and sulphur that you were referring to?

"A. If the oxygen enters deeply into the bath, there is too little oxygen available where the slag is formed and this prevents the slag from being fluid, it keeps the iron oxide content low. The operator would say he had a dry slag.

"Q. Is a dry slag good for phosphorus removal?

"A. No. It is neither fluid nor highly oxidizing."

[26] (Also see *infra,* II. C (3).)

Defendant's witnesses admit that a deep penetration of the bath by the jet prevents satisfactory phosphorus removal. Mr. Johnson, for example, testified as follows (R. 3483-85):

"Q. It is true, is it not, Mr. Johnson, that during at least the early part of the blow and for a substantial portion of the blow, it is necessary to operate with the lance in what would be termed a high position in order to enable you to get rid of the phosphorus?

"A. To be more specific, it is necessary to melt some of the slag from constituents as early as possible, and the higher lance position would assist in doing that.

"Q. You have to have, as you put it, a higher lance position in order to enable you to get a fluid slag early in the operation in order to enable you to adequately get rid of the phosphorus. Is that a fair statement?

"A. We want to melt some of the slag from constituents as soon as possible so that phosphorus reduction can start.

"Q. And the way that you do that is by utilizing a high lance position at the outset?

"*Mr. Groner*: 'High' being used relatively?

"*Mr. Webb*: Yes.

* * *

"Q. As a matter of fact, it is true, is it not, that the reason why you operate at the higher lance level in the earlier portions of the blows in your No. 1 and No. 2 Shops than you do later on in the blow is because you want to get the fluid slag so that you can get the phosphorus removal. Right?

"A. Partly, and also partly because the height of the material in the vessel is higher at that time.

* * *

"Q. Shall we say, then, that that is one factor, but that the principal reason for operating **[27]** at the higher lance position throughout a substantial portion of the blow, and particularly at the earlier stages of the blow, is that you want to get a fluid slag so that you can get rid of the phosphorus?

"A. The intention in the operation is to start melting some of the slag as soon as possible, yes.

"Q. And for what purpose then?

"A. So that phosphorus reduction will start.

"Q. How long does that phosphorus reduction continue?

"A. Depending on the temperature of the slag, it can continue during the entire heat or stop and start.

"Q. As a matter of fact, it is important that you do get rid of the phosphorus, or as much of it as you can, in your operation because of the fact that your customers require low phosphorus in the steel in order that it will have the properties desired by them?

"A. Yes."

Also, the testimony of Mr. Horsley, McLouth's General Superintendent of the Hot Metals Division, is significant in this regard. Specifically, he testified (R. 6692-93):

"Q. Yes. And during the course of the blow, on occasions the lance height was lowered. What is the reason why that lance is lowered during the course of the blow?

"A. Normally, we will start a blow with an elevated lance position to flux the slag. After the foreman feels the slag is fluxed, he will start lowering his lance, increasing the flow, or one or the other, and that is to achieve penetration of the metal.

* * *

"Q. There are occasions when the lance is raised during the course of the blow. What is the purpose of raising the lance during the course of the blow?

"A. I remember one heat in particular on the days you were there that the lance was raised, [28] and that particular heat, I don't recall the heat number, was due to a dry slag.

"Q. Well, from time to time in the regular operations on other occasions, they do raise the lance, do they not?

"A. It will happen if they need to flux or make their slag a little thinner; and also it will happen on a heat where they stop a blow on a higher carbon, they raise the lance to flux the slag just before they shut off the oxygen.

"Q. And the purpose in that instance is what?

"A. To thin the slag.

"Q. And what does the thinning of the slag do?

"A. Build up the FeO in the slag.

"Q. And for what purpose?

"A. For phos reduction.

"Q. The higher lance positions are necessary during the operation in order to enable you to get a good, thin slag which will enable you to remove the phosphorus?

"*Mr. Groner*: You mean in all operations or the particular ones that he was just refering to where the lance was raised?

"*Mr. Webb*: In all operations.

"A. Mr. Webb, our intent is to start the blow at an elevated lance position in order to build up the

FeO in the slag in order to have a thin slag, then decrease the lance position or lower the lance and increase the flow to penetrate the bath after the slag has been fluxed. It is true you need a fluid slag for phos or sulphur reduction.

"Q. And the way you get that, as I understand your testimony, is by this higher lance position?

"A. That is our method of getting it."

The testimony of Mr. Johnson and Mr. Horsley is consistent with the teaching of the specification at col. 6, lines 5 to 19, concerning the desirability of an early fluid slag for [29] satisfactory phosphorus removal. The specification of the patent in suit also teaches the avoidance of deep penetration, in contradiction to the teachings of the Schwarz patent, and, further, the specification of the patent in suit at col. 3, lines 70-75, associates the avoidance of deep penetration with the fluid slag necessary for satisfactory phosphorus removal. The Schwarz patent teaches nothing about the necessity of a fluid slag for phosphorus removal or its connection with the avoidance of deep penetration. Thus the teachings of the patent in suit are certainly not "identically disclosed or described" by the Schwarz patent.

In view of the unspecific teachings of the Schwarz patent and its lack of detail concerning operating conditions, as well as the apparent inability of steelmakers including Dr. Durrer and the patentees to make satisfactory stéel following the ideas of the Schwarz patent, it cannot be said that the Schwarz patent teaches the invention disclosed in the patent in suit in such full,

clear and exact terms as to enable persons skilled in the art to practice the invention without further experiment. Moreover, the Schwarz patent does not teach the invention claimed in the Suess patent. Schwarz teaches nothing about the avoidance of material agitation of the bath by the oxygen stream or a circulation of the bath produced by chemical reactions in a localized reaction zone, as claimed by the patent in suit. The conclusion is therefore, inescapable that the patent in suit is not anticipated by the Schwarz patent under 35 U.S.C. § 102.

(2) THE MILES PATENT

The Miles Belgian patent (DX 61, Miles) teaches a process of blowing fluid containing from 70% to 98% oxygen (DX 61, Miles, p. 2) downwardly into a bath of molten pig iron. [30] preferably at an angle between 30 and 75 degrees (p. 17), so that the major part of the fluid jet penetrates into the bath (p. 3), serving to circulate and agitate the metal and slag. (p. 18.) The gist of the invention appears to be the teaching of blowing upon the surface of the metal at a velocity which is sufficiently high to assure the penetration of almost all the fluid into the bath, so as to react with the oxidizable impurities of the metal and eliminate them. (pp. 2, 20). According to the patent: "The course of the refining can be controlled by varying the inclination of the jet with respect to the surface or by varying the velocity of the gases or their composition." (p. 4.) In a specific example, the Miles patent teaches the use of a nozzle of 0.32 inches inside diameter, operated at an oxygen pressure of 7 or 8 atmospheres and spaced 6 inches above the surface of a molten metal bath, to obtain the desired penetration of the bath by the jet. (p. 3.) The invention of the Miles patent is applied in its specification to the

Bessemer process in various manners; thus, in effect, a variety of steelmaking processes are suggested in the specification. For example, the specification suggests the use of a normal basic Bessemer blow "until the end of the carbon flame period after which the converter is tipped downward, the air feed is cut off and a high speed jet of oxygen and nitrogen in liquid or gaseous state is projected in order to oxidize the remaining impurities." (p. 5.) In another example, the patent states that "It becomes needless to provide the Bessemer with the usual bottom if the high speed jet is injected into the bath of molten metal through one or more tuyeres, the nozzles of which are located a few inches above the surface of the metal bath." (p. 7.)

[31] It cannot be said that the teachings of the Miles patent identically disclose the invention of the Suess patent in suit in such full terms as to enable persons skilled in the art to practice the invention without further experiments.

In the first place, the teachings of the Miles patent are tentative and leave open a number of possibilities, some of which are recommended over others. Certain of the operating conditions of the patent in suit are included within the broad range of possibilities taught by Miles, but are not necessarily recommended by Miles. Thus Miles teaches that "The jet is established at any angle between 15° and 90° with respect to the horizontal, but preferably between 30° and 75°, while the distance from the jet to the metal and/or the slag should be between 1 and 20 inches, preferably between 4 and 12 inches." (p. 17.) In contrast, the patent in suit teaches and claims only vertical blowing, which is not recommended by Miles, and also teaches a range of

nozzle bath distances from 6 to 80 inches, which only partially overlaps the range of distances taught or recommended by Miles. Further, the patent in suit teaches and claims only the use of pure oxygen gas, but Miles teaches the use of an "oxidizing fluid" which may be either liquid or gas and which may contain as much as 30% nitrogen. (p. 2.) Miles appears to recommend the use of liquid rather than gas by stating: "one of the advantages afforded by the use of a liquid instead of a gas for the jet is that the liquid has a greater force of penetration into the metal; if desired, therefore, the projecting tuyere can be maintained at a greater distance from the metal. Another advantage results from the fact that the oxygen-nitrogen [32] mixture is produced in liquid state during normal manufacture and can be transported and stored more economically than a gas." (p. 2.) Miles also apparently recommends a certain percentage of nitrogen in the fluid used. Thus the patent states: " . . . it has been found that it is too costly to employ a fluid containing more than 98% oxygen so that in effecting the present invention, the relation of nitrogen to oxygen in the refining fluid has been kept between 30/70 and 2/98. The preferred percentage of nitrogen is between 5% and 25% . . . " (pp. 4-5.)

In sum, a person skilled in the art would have to depart from the recommendations of the Miles patent in respect to blowing angle, blowing distance, the use of liquid rather than gas and the chemical composition of the oxidizing fluid in order to arrive at the teachings of the patent in suit. Although the patent teachings of vertical blowing pure oxygen gas from a distance of at least six inches are not expressly precluded by the teachings of the Miles patent, a person skilled in the

art, starting with the Miles patent, would certainly require considerable further experiment to arrive at such teachings of the patent in suit in order to practice the invention. The differences already mentioned between the Miles patent and the patent in suit are alone sufficient to dispose of the contention of anticipation by Miles.

In addition, Miles' suggestions of a variety of processes, including examples using more than one jet, would require a person skilled in the art reading the Miles patent to experiment with the various suggestions to determine which, if any, are satisfactory.

[33] Moreover, the Miles patent does not contain certain essential teachings of the patent in suit, and indeed contains teachings inconsistent therewith. For example, Miles teaches that the major part of the jet penetrates into the bath (p. 3), serving to circulate and agitate the metal and slag. (p. 18.) The patent in suit, on the other hand, claims a process which avoids material agitation of the bath by the jet and includes a circulation caused by chemical reactions rather than the action of the jet. Further, the patent in suit teaches the avoidance of a deep penetration into the bath by the oxygen jet (e.g., col. 3, line 74.) In general, the teachings of the Suess patent concerning operating conditions are more specific and detailed than those of Miles. For example, the patent in suit (at col. 3, lines 56-7) teaches a range of blowing pressures from 5 to 25 atmospheres of pressure, but Miles contains no such teaching. Additionally, in col. 10, the patent in suit teaches an exemplary operation in great detail concerning the quantity and composition of pig iron and scrap used and slag material added, blowing pressure and

nozzle diameter, nozzle bath distance, blowing time, oxygen consumption and efficiency, and chemical composition of the steel produced. Miles teaches no such detailed example producing satisfactory steel.

According to Dr. Durrer, Miles' work led to no practical results in steelmaking (R. 5085), and Dr. Chipman testified that the Miles disclosures did not describe a practical operating method for making steel. (R. 1019.) There is no evidence in the record to the contrary. In fact, there is admittedly no evidence in the record that steel of the quality now produced at [34] Linz and at the McLouth plant in Trenton, Michigan, was produced anywhere in the world by an oxygen top blowing process prior to June of 1949. (R. 13,484-86.) Dr. Durrer and Dr. Hellbruegge were familiar with Miles' work, and yet even with further experimentation consisting of more than 100 heats by the spring of 1949, they apparently failed to produce steel comparable in quality to that produced in Linz (See *infra*, II, C (3).) Moreover, the patentees were admittedly familiar with the Miles patent in early June of 1949 (DX 116, p. 2; DX 117, p. 2), but the patentees also required further experimentation to produce satisfactory steel. It is true that heats No. 21 to 24 of the June, 1949, tests at Linz, which produced good steel, used a nozzle diameter, blowing pressure and nozzle bath distance almost identical with the example suggested by the Miles patent. (See DX 116-A.) However, the example of the Miles patent mentioned a jet speed of 1250 feet per second, somewhat faster than the speed of sound. (DX 61, Miles, p. 3.) Such a supersonic speed of the jet would require the use of a so-called Laval nozzle (R. 2863-67), and therefore the fair implication of the teaching of a supersonic jet

speed by Miles is the teaching of the use of a Laval nozzle. The Miles patent also states that lower speeds can be used, but does not expressly approve even subsonic speeds for purposes of the example. The patentees used a normal nozzle rather than a Laval nozzle in their heats 21 to 24, which otherwise followed the teachings of the Miles example. (DX 116-A.) According to the Rinesch affidavit, the use of the normal nozzle resulted in a subsonic jet speed of 280 meters or roughly 919 feet per second (DX 116, p. 4), over 300 feet per second slower than the speed [35] suggested by Miles. This difference in jet speed would materially reduce the impact pressure of the jet and therefore the penetration of the jet into the bath. Such a difference in penetration is consistent with the difference in teaching between the Miles patent and the Suess patent with regard to penetration. Although Miles does not expressly teach "deep penetration", as does Schwarz, it is agreed that Miles' teachings are essentially the same as Schwarz' and that a person following Miles' teachings will obtain a deep penetration of the bath by the jet (e.g., R. 107-08). The patent in suit, on the other hand, teaches the avoidance of deep penetration, and the record indicates that such avoidance of deep penetration is in fact the gist of the invention by the patentees. (See *infra,* II B (2); II E (1).)

In addition to the absence of proof in the record that persons skilled in the art following Miles' teachings were able to make satisfactory steel, there is also the affirmative evidence that deep penetration as taught by Miles cannot in fact lead to good results in steelmaking, because the early fluid slag necessary for adequate phosphorus removal is not formed with a deep penetration

of the bath by the jet, as already discussed in connection with the Schwarz patent.

In short, the Miles patent cannot be said to anticipate the patent in suit for a number of reasons: the patent in suit contains specific and detailed operating conditions and teachings either not found in Miles or not recommended by Miles, or contradicting the teachings of Miles; and, further, the evidence in the record indicates that Miles' teachings did not and indeed could not lead to good results in steelmaking comparable to those achieved by the patentees.

[36] (3) THE POTTS PATENT

Since defendant has apparently withdrawn its reliance on the Potts British patent (DX 61, Potts) as anticipating the patent in suit, a lengthy discussion of this patent is unnecessary. Potts teaches that "The jet is preferably directed onto the surface of the metal at an angle," and that "The jet device is usually placed in the furnace in such manner that the nozzle is approximately at the slag surface or slightly submerged therebelow, although good results have been obtained with the nozzle placed approximately 3 to 6 inches above the slag surface. The oxygen jet, when at a velocity above sonic speed, tends to penetrate the slag and metal and to form a well-defined cavity or recess in the surface of the molten metal." (DX 61, Potts, p. 3.) Clearly the essence of Potts' teaching is inclined blowing at supersonic speed, resulting in a deep penetration of the bath by the jet. Such teaching does not anticipate a teaching of vertical blowing from at least 6 inches above the bath, so as to avoid deep penetration of the bath by the jet. Further, Potts does not teach the range of operating

conditions of the patent in suit, nor is there any evidence that Potts' process led to any practical results in steelmaking.

(4) CONCLUSION

On the issue of anticipation by prior art, defendant's position has shifted several times in the course of this litigation. As already noted, the pretrial order stated as a defense anticipation of the patent in suit by the Schwarz, Miles and Potts patents. On the opening statement, defendant stated a defense of "no invention over Schwarz and Miles," a vaguely [37] worded defense which could include either lack of novelty under § 102 or obviousness under § 103. However, on opening statement, counsel for defendant continued, stating:

> "Mr. Webb adverted yesterday to the fact that we did not claim that Schwarz and Miles blanketed or anticipated the patent in suit. Of course not. They were practical men with a practical method of operation. They taught oxygen blowing as it is practiced. They weren't compelled to resort to the subterfuges of the patent in suit. They didn't have any absurdities about the avoidance of material agitation. So there are differences between the patent in suit and Schwarz and Miles.
>
> "But to the extent that the patent in suit departs from Schwarz and Miles it is pure phoney, non-practiced, non-known, in any commercial operation in the world." (R. 143-44.)

This statement appears to have been a waiver of any defense of anticipation by Schwarz and Miles.

On final arguments, the Court expressed some confusion as to whether defendant was relying on anticipation or obviousness, stating:

> "I don't know for sure—I haven't heard, of course, from the defendants—but after reading the briefs, I got that impression; that their main thrust here is more that this was, in fact, anticipated by Schwarz and Miles and the teachings of Durrer and Hellbruegge, rather than admitting that this is some advance in the art and yet it doesn't arise to the level of invention."

Counsel for defendant then expressed agreement with the Court's statement, so as to give the impression defendant was relying on a defense of anticipation after all. (R. 13,161-2.) This impression was strengthened (R. 13,409) when counsel for defendant stated that plaintiffs' "operation, so far as it is known in commercial exemplification, is simply and solely what was known before them by Schwarz and by Miles." The Court then asked counsel for defendant: "Well, now, in view of that statement, [38] is it your position that the patent in issue is anticipated by Schwarz and Miles?" and counsel answered: "If it please your Honor, we proved defenses under Section 102 and under Section 103."

However, shortly thereafter the following colloquy occurred:

> "[*Counsel for defendant*]: Our defense has been largely built around the defense of Section 103, that no invention is shown in the patent in suit over the prior art. We have done that despite having pleaded that it was anticipated because of the ex-

crescences on the patent that are not duplicated in the prior art.

"*The Court*: Well, now, there is a difference between anticipation and whether there is invention over the prior art.

"[*Counsel*]: Yes, your Honor; I recognize it.

"*The Court*: Now, which do you rely on?

"[*Counsel*]: We rely on section 103, if it please your Honor, that there is no invention.

"*The Court*: The test of invention.

"[*Counsel*]: Yes, sir.

"*The Court*: You are not relying on anticipation, then?

"[*Counsel*]: Not specifically." (R. 13,409-10.)

At R. 13,710, the Court once again asked counsel for defendant: "Do you contend Schwarz and Miles anticipate Suess?" and counsel answered: "No, your Honor, because in the patent in suit there are these erroneous fictitious statements about avoiding deep penetration and that sort of thing, which are just the contrary of Schwarz and Miles. Actually I think it is true that the patent in suit adopted that talk about the avoidance in order to try to keep Schwarz off their neck."

Defendant's briefs after trial are unclear whether anticipation or obviousness is urged as a defense, almost to the [39] point of being deliberately vague. Thus defendant's main brief argues: "Efforts to differentiate the patent from the prior art Schwarz and Miles patents get nowhere because the patent is silent on the points of asserted difference. The patent in suit is invalid over Schwarz and Miles." (p. 223.) Defendant's reply brief argues: "The patent in suit, stripped of its inaccuracies, and disregarding its unresolvable ambiguities, is undistinguishable from the Schwarz and Miles patents. The patent discloses no invention over Schwarz or Miles and is invalid." (p. 40.)

The Court might justifiably have relied entirely on defendant's statements at R. 143-44, 13,410 and 13,710, waiving any defense of anticipation by prior art. However, in view of defendant's somewhat ambivalent attitude concerning this defense, the Court felt obliged to decide the issue on the evidence. As already discussed, it is the opinion of this Court that defendant has not carried its heavy burden of showing that either the Schwarz or Miles patents alone identically disclosed the invention of the patent in suit in such full, clear and exact terms as to enable persons skilled in the art to practice the invention without further experiment. In other words, the Court finds that the patent in suit is not anticipated by prior art.

B. Nonobviousness

In 1952, Congress enacted Section 103 of 35 U.S.C., which provides:

> "A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the

invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made."

[40] By enacting section 103, Congress added a third statutory requirement of 'nonobviousness' to the two requirements of novelty and utility that had been codified as long ago as the Patent Act of 1793. However, a similar requirement of 'invention' had been established by judicial precedent as early as 1850 in the Supreme Court's opinion in *Hotchkiss v. Greenwood,* 11 How. 248, 267 (1850), stating:

". . . unless more ingenuity and skill . . . were required . . . than were possessed by an ordinary mechanic acquainted with the business, there was an absence of that degree of skill and ingenuity which constitute essential elements of every invention."

In the recently decided case of *Graham v. John Deere Co.,* 383 U. S. 1 (1966), the Supreme Court held that Section 103 of the Patent Act was intended to codify the principle of the *Hotchkiss* case, "and that, while the clear language of § 103 places emphasis on an inquiry into obviousness, the general level of innovation necessary to sustain patentability remains the same." (383 U. S. at p. 4.)

It must be noted that in this case, "the time the invention was made" for purposes of section 103 must be considered as the time of the filing date of the first patent application in a foreign country, since under sec-

tions 104 and **[41]** 119 of 35 U.S.C.[3] a foreign inventor may not establish a date of invention earlier than his first filing date in a foreign country, assuming such date is earlier than the filing date in this country. As the Court stated in *Monaco v. Hoffman,* 189 F. Supp. 474, 481 (D.C. Dist. Col. 1960):

"Sections 104 and 119 must be read together. They are *in pari materia.* The effect of the two provisions is to accord to a foreign inventor the benefit of the

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3. These sections provide, in pertinent part:

"§ 104. *Invention made abroad*

"In proceedings in the Patent Office and in the courts, an applicant for a patent, or a patentee, may not establish a date of invention by reference to knowledge or use thereof, or other activity with respect thereto, in a foreign country, except as provided in section 119 of this title."

"§ 119. *Benefit of earlier filing date in foreign country; right of priority*

"An application for patent for an invention filed in this country by any person who has, or whose legal representatives or assigns have, previously regularly filed an application for a patent for the same invention in a foreign country which affords similar privileges in the case of applications filed in the United States or to citizens of the United States, shall have the same effect as the same application would have if filed in this country on the date on which the application for patent for the same invention was first filed in such foreign country, if the application in this country is filed within twelve months from the earliest date on which such foreign application was filed; but no patent shall be granted on any application for patent for an invention which had been patented or described in a printed publication in any country more than one year before the date of the actual filing of the application in this country, or which had been in public use or on sale in this country more than one year prior to such filing."

filing date of his first application in a foreign country, instead of limiting him to his later filing date in the United States. On the other hand, such an inventor may not avail himself of a still earlier date of invention abroad."

[42] Although the patentees now contend that the subject matter of the patent in suit was invented in June of 1949, the "time the invention was made" must be considered as January 31, 1950, the filing date of the first application by Dr. Suess in Austria. (PX 2C.)

It must be noted also that the most pertinent prior art references for purposes of section 103 are, again, the Schwarz and Miles patents. Although the pretrial order also listed the Potts British patent as pertinent prior art, only the Schwarz and Miles patents were discussed in the opening statements, briefs after trial or final arguments as pertinent to the issue of obviousness.

The work of Drs. Durrer and Hellbruegge creates no issue as to the obviousness of the invention by the patentees, since such work does not constitute prior art under section 103. Both the statutory language and legislative history of section 103 made clear that the term "prior art" as used in section 103 refers only to "what was known before as described in section 102." S. Rep. No. 1979, 82d Cong., 2d Sess. (1952) at 6; H. R. Rep. No. 1923, 82d Cong., 2d Sess. (1952) at 7. Prior use in a foreign country is not prior art as set forth in section 102, which section refers, among other things, to inventions "known or used by others" or "in public use or on sale" in this country only, and makes no mention of inventions known, used or sold by others in a foreign country. Furthermore, defendant has admitted that

the work of Dr. Durrer and Dr. Hellbruegge is not a prior use which could invalidate the patent in [43] suit,[4] and that "use in a foreign country is of no legal effect as far as this lawsuit is concerned," (R. 4555-56). Hence, this Court is not faced with the question whether the subject matter of the patent in suit would have been obvious to persons skilled in the art familiar with the work of Dr. Durrer and Dr. Hellbruegge.

Thus the issue under section 103 in this case is whether the subject matter as a whole of the patent in suit would have been obvious to persons skilled in the art of steelmaking familiar with the Schwarz and Miles patents on or about January 31, 1950, the filing date of the Austrian application by Dr. Suess. As already noted, defendant's burden of proof on this issue of validity is a "heavy burden" requiring "more than a dubious preponderance" to satisfy. *Williams v. United Shoe Co.*, 121 F. 2d 273, 277 (CA 6, 1941). To resolve the issue of nonobviousness, the Court feels obliged to consider the differences between the subject matter as a whole of the claims of the patent in suit and the per-

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4. In defendant's main brief, p. 225, it is admitted that ". . . the work of Drs. Durrer and Hellbruegge is not, within the purview of the Patent Law of the United States, a prior use, and they are not prior patentees or prior publishers," and further states: "McLouth relies on the work of these two witnesses for the sole purpose of showing that the patentees of the patent in suit are not inventors. It is understood that when the proofs concerning Dr. Durrer and Dr. Hellbruegge are restricted to this issue, the plaintiffs do not dispute the rule that the patentees must be the true inventors." Also, in defendant's reply brief, pp. 33 and 41, it is admitted that a foreign prior use cannot be used to invalidate a United States patent.

tinent prior art, and also other objective evidence of obviousness or nonobviousness such as commercial success, for example. As the Supreme Court recently stated in the *Graham* [44] case, *supra,* 383 U. S. 1, 17-18 (1966):

> "While the ultimate question of patent validity is one of law, *A. & P. Tea Co. v. Supermarket Corp., supra,* at 155, the § 103 condition, which is but one of three conditions, each of which must be satisfied, lends itself to several basic factual inquiries. Under § 103, the scope and content of the prior art are to be determined; differences between the prior art and the claims at issue are to be ascertained; and the level of ordinary skill in the pertinent art resolved. Against this background, the obviousness or nonobviousness of the subject matter is determined. Such secondary considerations as commercial success, long felt but unsolved needs, failure of others, etc., might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented. As indicia of obviousness or nonobviousness, these inquiries may have relevancy."

Further, as Judge Learned Hand stated in *Reiner v. I. Leon Co., Inc.,* 285 F. 2d 501, 503-04 (CA 2, 1960):

> "The test laid down is indeed misty enough. It directs us to surmise what was the range of ingenuity of a person 'having ordinary skill' in an 'art' with which we are totally unfamiliar; and we do not see how such a standard can be applied at all except by recourse to the earlier work in the art, and to the general history of the means available at the time. To judge on our own that this or that new assemblage of old factors was, or was not, 'obvious' is to substitute our ignorance for the acquaintance with the subject of those who were familiar with it. There are indeed some sign posts: e.g. how long did the need exist; how many tried to find the way; how long did the surrounding and accessory arts disclose the means; how immediately was the invention recognized as an answer by those who used the new variant?"

(1) THE PRIOR ART AND THE INVENTION BY THE PATENTEES

As already discussed, the Schwarz German patent and the Miles Belgian patent taught and claimed processes of steelmaking involving blowing oxygen into a bath of molten pig iron from above. Schwarz taught blowing deeply into the bath in the manner of a solid body (DX 61, Schwarz, p. 2) and, although Miles [45] did not expressly teach "deep" penetration, it is conceded by the parties that Miles' teachings involved a deep penetration of the bath by the jet (e.g., R. 108). With regard to the blowing, the angle of the jet in the Schwarz patent is unspecific and the Miles patent recommends blowing at an angle of between 30 and 75 degrees. (DX 61, Miles, p. 17.) The Miles patent teaches that the action of the jet itself agitates and circulates the bath (DX 61, Miles, p. 18), but the Schwarz patent contains no such teaching. Both the Schwarz and Miles patents contain reference to a limited center of chemical reactions in the bath caused by contact of the jet with the bath surface. (DX 61, Schwarz, pp. 4-5; Miles, pp. 3, 15, 16.) Additionally, both the Schwarz and Miles

patents teach that the danger of excessive refractory wear is avoided in their methods of steelmaking because the chemical reactions take place at the center of the bath, away from the refractory lining. (Schwarz, pp. 4-5; Miles, p. 3.) The parties agree that the gist of the teachings of both the Schwarz and Miles patents is the necessity of penetration deep into the bath by the oxygen jet.

As already noted, according to the testimony of Dr. Durrer, the teachings of both the Schwarz and Miles patents led to no practical results in commercial steelmaking. (R. 5085.) The work of the patentees at Linz, Austria, on the other hand, has resulted in a commercially successful process of steelmaking, admittedly adopted by defendant in this case and presently used throughout the world.

If the process perfected at Linz had been obvious to steelmakers familiar with the Schwarz and Miles patents, it is [46] difficult to understand why satisfactory low phosphorus steel would not have been produced earlier than 1949. The Schwarz patent issued in 1943, and the Miles patent in 1947. At this time, there was considerable interest in developing for commercial use new methods of steelmaking involving the use of oxygen. The invention in 1928 of the so-called Linde-Fraenkl process for the production of pure oxygen made feasible the invention of new processes of steelmaking involving the use of pure oxygen. (R. 5068.) Experimentation to this end began as early as the 1930's, resulting, for example, in the Schwarz patent application in 1939. According to Dr. Durrer, numerous men experimented with oxygen refining in the 1930's

and 1940's, but their efforts did not lead to any practical results. (R. 5064-86; 5111-37.) It is disputed at what point in time pure oxygen became available in large quantities for use in commercial production of steel. Defendant contends that oxygen did not become available inexpensively in large quantities until the late 1940's, so as to inhibit the development of a commercial oxygen steelmaking process before that time. Conflicting evidence on the point leaves this Court unable to fix with certainty any date on which oxygen became available inexpensively in large quantities for commercial production of steel. However, in light of the limited experimentation with oxygen in steelmaking as early as the 1930's, the alleged unavailability of oxygen for commercial production before the late 1940's would not necessarily have been an inhibiting factor on experimentation with oxygen in steelmaking. The incentives to find a satisfactory oxygen steelmaking process were substantial, in view of the high capital and operating costs as well as the relatively slow production rates of the open hearth process. Yet there is [47] admittedly no evidence in the record that satisfactory low phosphorus steel was produced even experimentally prior to the June, 1949, tests at Linz, Austria, by the patentees. (R. 13,484-86.) Further it appears from the record that the first successful commercial operation involving an oxygen blowing process of steelmaking was installed at Linz in November, 1952. (PX 342, p. 12; PX 95, p. 783.)

The substantial advantages of the Linz oxygen blowing process of steelmaking quickly became apparent. The quality of the steel produced was com-

parable to open hearth steel, while capital and operating costs were considerably reduced. Therefore, steelmakers from all over the world came to Linz to familiarize themselves with the new Linz process. (PX 342, p. 12.) The reaction of steelmakers to the Linz process was one of initial skepticism followed by recognition of the invention and adoption of the process. Dr. Durrer stated in a memo as early as December 14, 1949, that the work at Linz "contradicts all metallurgical expectations," and "shows a new metallurgy with which we must first of all become acquainted." (DX 89B (20).) Defendant McLouth, which now contends that the process at Linz would have been obvious to steelmakers familiar with the Schwarz and Miles patents, paid $100,000 for know-how relating to the Linz process, but explains this expenditure by claiming unfamiliarity with the prior art at the time. (R. 13,818.) Such explanation is not entirely convincing, in view of McLouth's far ranging search for the most desirable method of steelmaking available, a search which involved a trip to Europe by Mr. Lindberg of McLouth. Defendant, having decided to "integrate the Austrian process into its steelmaking operations" (PX 98D; R. 1118), copied the design of the Linz operation (R. 3490-91), and proceeded to construct its OP-1 [48] shop without further experimentation of its own. (R. 3507.) However, McLouth also spent large sums to construct duplexing equipment for steelmaking in case the Linz process did not prove satisfactory. The duplexing equipment proved unnecessary, and was eventually taken out of service. (R. 3542-44, 1296-1300.) As Mr. Bryn, McLouth's President, testified (R. 1297):

"Q. In other words, even at that time you weren't sure whether by this new process you would be able to produce steel of adequate quality to meet your demands?

"A. That's right.

• • •

"Q. And I gathered from your statement that you were not sure at the time as to whether or not you would be able to get a product comparable with the product of the open hearth process?

"A. That's right. That's the reason we spent the dough to make it possible to duplex or *otherwise we wouldn't have thrown that dough out the window.*" (Emphasis added.)

The remarkable success of the Linz process is dramatically illustrated by the fact that no open hearth furnace has been built in this country since 1953, when knowledge of the Linz process became available in this country. (R. 5922-23.) As already mentioned, more than 75% of all new steelmaking facilities since 1954 or now in the planning stage are Linz process installations (PX 342, p. 13); 16 steel companies in the United States alone have either begun or planned commercial production using the basic oxygen process in use at Linz (PX 104, p. 3); and 64 companies in 23 foreign countries have installed the process. It was estimated at trial that the basic oxygen steelmaking annual capacity in this country as of January 1, 1966, would be roughly 32 million tons. (R. 5871-72.)

[49] In short, there was a striking difference in the results achieved by the process developed and practiced at Linz as compared with the results of the prior art,

and particularly the Schwarz and Miles patents. As recently stated by the Sixth Circuit Court of Appeals in the case of *Simplicity Manufacturing Co. v. Quick Mfg., Inc.*, 355 F. 2d 1012, 1015-16 (1966), the patentee's "ingenuity and resourcefulness brought about a result which the prior art inventors were unable to conceive or anticipate."

There was apparently some confusion even among the patentees themselves as to the true explanation for such difference in result. As Dr. Hauttmann said in his affidavit submitted to the Patent Office (DX 117, p. 3): "While the advantages of the new method were appreciated at once, a completely satisfactory explanation for the improved result was not readily apparent."

Dr. Suess filed patent applications in many countries, including the United States application dated January 16, 1951, claiming the gist of the invention to be the maintenance of a certain proper ratio between the bath depth and surface area. However, in his original Austrian application dated January 31, 1950 (PX 2C), and also in the first four claims of his United States continuation in part application (PX 2A), Dr. Suess claimed the avoidance of deep penetration in the bath by the oxygen as the essence of the invention. Two of the other patentees, Dr. Hauttmann and Dr. Rinesch, apparently also shared this theory, at least in 1957 when they presented affidavits to the Patent Office. The Rinesch affidavit states that the patentees determined in the June, 1949, tests at Linz "that a satisfactory refining operation could be obtained so long as the oxygen jet does not penetrate deeply into the bath." (DX 116, [50] p. 4.) The Hauttmann affidavit considered the invention to be the creation of a limited center of reaction "substantially in the surface layer" resulting in a controlled circulation of the bath. (DX 117, pp. 3-4.) Dr. Hauttmann also expressed his opinion that the limited center of reaction and circulation was brought about by the avoidance of deep penetration. (DX 117, pp. 4-5.) Dr. Trenkler, the other patentee, testified that the only significant difference in practice over prior teachings was a reduction of the impact pressure of the jet and, therefore, a lesser penetration into the bath by the jet than would have resulted from prior teachings. (R. 11,905.) Thus, at one time or another, all four of the patentees expressed their understanding that the avoidance of deep penetration was the basis of a successful oxygen steelmaking process.

(2) The meaning of "the avoidance of deep penetration"

Clearly, the phrases "deep penetration" and "avoidance of deep penetration" have no precise meaning. Further, it is apparent that these phrases have been given different meanings by various peopie since the Schwarz patent first used the phrase "deep penetration" in 1943. As Mr. Justice Holmes once said: "A word is not a crystal, transparent and unchanged; it is the skin of a living thought and may vary greatly in color and content according to the circumstances and the time in which it is used." *Towne, v. Eisner*, 245 U. S. 418, 425 (1918). Thus the word "deep" has received a variety of definitions in regard to penetration of the bath depending on the motives of the person defining the word.

To Schwarz, deep penetration apparently meant penetration of the bath sufficient to avoid a mere surface reaction of [51] the jet. The Schwarz patent states:

"Surface contact is not sufficient in most cases to produce a rapid reaction, such as the blowing of the gas over the surface of the bath or the mere blowing of the gas onto the surface of the bath." (DX 61, Schwarz p. 1.) Dr. Durrer and Dr. Hellbruegge apparently had a similar underdstanding of the term "deep penetration." (See DX 61, Hellbruegge, *Stahl und Eisen* Article, pp. 5, 7.) Demonstration number six at Ann Arbor, Michigan, during the trial of this litigation, established that such a surface reaction is not satisfactory for steelmaking because of a dangerous slopping condition that results, and also the poor quality of the steel produced. For Schwarz, "deep" penetration did not mean sufficient penetration to cause refractory damage. The Schwarz patent states:

> "In the refining of steel with oxygen-enriched air or oxygen, when using the method in accordance with the invention, the danger of rapid wear of the container liner is eliminated since the reaction between oxygen and iron or iron-accompanying substances with the phenomena resulting therefrom, namely local overheating and accumulation of ferrous oxide, takes place in the center of the steel bath and therefore, the walls of the vessel are not substantially attacked." (DX 61, Schwarz, pp. 4-5.)

Miles, also, taught that the penetration of the jet should stay "at a good distance from the refractory lining of the furnace" so as to avoid refractory wear. (DX 61, Miles, p. 3.)

Dr. Suess in his many patent applications mentions the avoidance of deep penetration as desirable. The original Austrian application explains that deep penetration would result "in an undesired reaction of the

slag due to the strong swirling motion and that it would reduce the surface lining considerably." (DX 2C, p. 2.) However, when the Suess application in Germany was faced with opposition by the Schwarz patent, Dr. Suess attempted [52] to distinguish the Schwarz patent as follows:

> "In contradistinction to [Schwarz], in the case of the process of the present invention the molten bath is blown with so little kinetic energy that the oxygen does not penetrate. The movement of the bath is caused solely by chemical reactions on the surface. As soon as they are at an end, no penetration of the oxygen and no movement of the bath take place." (DX 93 B, pp. 31-32.)

Thus, Dr. Suess attempted to distinguish his German application from the Schwarz patent by defining the avoidance of deep penetration as no penetration at all. Similarly, Dr. Rinesch and Dr. Hauttmann were faced with the problem of distinguishing the prior art in prosecuting the United States Patent Application in 1957. The Rinesch affidavit states:

> ". . . our concept of avoiding deep penetration of the molten metal with the oxygen blast is just the opposite of the methods disclosed in the Schwarz and Miles et al. patents . . ." (DX 116, p. 7.)

Dr. Rinesch also said that deep penetration:

> ". . . creates an uncontrollable turbulence in the bath. The oxygen remains dissolved in the bath and the high oxygen content in the final steel leads to hot shortness or requires unsatisfactory quantities of deoxidizers. Furthermore, the phosphorous cannot be slagged off. Moreover, the walls, and par-

ticularly the bottom of the vessel become as hot as the reaction center and, therefore, are eroded severely." (DX 116, p. 6.)

Dr. Hauttmann in his affidavit stated:

". . . our concept of securing purification of the entire contents of the bath mainly by the controlled circulation induced by the reaction center is just the opposite of trying to carry the oxygen to all parts of the bath by agitation produced by deep penetration . . ." (DX 117, p. 5.)

Dr. Hauttmann's affidavit also associates deep penetration of the bath by the oxygen jet "with agitation producing injury to the lining and its consequent interference with the refining [53] action . . ." (DX 117, p. 3.) Thus, both Dr. Rinesch and Dr. Hauttmann contend in their affidavits that the subject matter sought to be patented involved avoidance of the deep penetration taught by Schwarz. However, both Dr. Rinesch and Dr. Hauttmann also define deep penetration with reference to agitation or turbulence of the bath, excessive refractory wear, and poor quality of the steel produced.

The first four original claims of the continuation-in-part application of the patent in suit, which expressly claimed the avoidance of deep penetration, were rejected by the Patent Office along with all other claims submitted at the same time as unpatentable over the prior art Miles patent. In response to this rejection, counsel for the applicants wrote a letter to the Patent Office attempting to distinguish the Miles patent by contending that the applicants' method differed from the Miles method "in emphasizing a much lower impingement

pressure and a practically negligible penetration of the surface of the molten metal by the oxygen jet." (PX 2 A, p. 68.) Clearly, the patentees and their attorneys defined the avoidance of deep penetration as practically no penetration at all in order to distinguish the prior art for purposes of prosecuting their own patent applications.

The specification of the patent in suit refers to the concept of avoidance of deep penetration in four different places (Col. 3, lines 46 and 74; col. 4, line 70; and col. 9, line 18.) Most significantly in column 3, lines 64 to 75, the patent teaches that the process, when conducted under certain specified operating conditions:

" . . . produces a sufficiently high reaction velocity of the oxygen with the bath constituents [54] to insure the development of autogenous heat at a rate sufficient to provide the heat required for completion of the refining in a minimum of time, consistent with controlled temperature and control and development of other *necessary and required process conditions, such as fluid slag, avoidance of overoxidation (undue loss of iron to the slag), and avoidance of slopping. The process conducted under these conditions avoids a deep penetration of the oxygen gas into the molten bath which seriously impairs refractory life at the bottom of the refining vessel.*" (Emphasis added.)

This important reference in the specification gives a new meaning to the phrase "avoidance of deep penetration" and at the same time discloses a crucial teaching of the patent in suit. According to this reference, the avoidance of deep penetration means a penetration suffi-

cient to avoid a surface reaction and slopping, and yet not deep enough to seriously impair refractory life at the bottom of the vessel, or to prevent the formation of the fluid slag which, according to the patent, is necessary for adequate phosphorus removal.

The claims of the patent in suit do not expressly refer to the concept of deep penetration or its avoidance. However, plaintiffs in this litigation contend that the avoidance of "material agitation of the bath by the oxygen stream" incorporates the idea of avoiding deep penetration. (E.g., plaintiffs' main brief, p. 268.) In the association of deep penetration with "material agitation" of the claims, plaintiffs now urge a broad definition of deep penetration as penetration sufficient to burn the bottom of the refractory. (E.g., plaintiffs' main brief, pp. 274-76.) However, such a definition ignores the further limitation placed on penetration by the specification of the patent in suit with regard to the formation of a fluid slag. [55] As already noted, the specification teaches that when a fluid slag is formed on the surface of the metal, deep penetration within the meaning of the patent is avoided. Thus, if a thick slag rather than a fluid slag is formed during the blowing operation, deep penetration within the meaning of the specification of the patent in suit is not avoided even though there may be no refractory damage.

There has been considerable disagreement as to the numerical degree of penetration taught by the patent in suit. Dr. Hauttmann testified that the process of the patent in suit involved a penetration of not more than one-half of the bath depth. (R. 2530.) Dr. Trenkler testified that penetration from one-third to one-half of

the bath depth would be the maximum penetration under the teachings of the patent in suit. (R. 11,911.) Dr. Elliott said that, in his opinion, "deep penetration arises when the jet enters more than, say, 35 to 40 per cent of the bath depth." (R. 6637.) Mr. Stone, on the other hand, said that he was sure only that a penetration of 90% to 100% of the bath would be deep penetration. (R. 7179.) Defendant's witness, Dr. Flinn, stated that the patent teachings would not enable him to assign any quantitative meaning to the term "deep penetration." (R. 8014-15.)

It must be noted at this point that defendant claims to be practicing deep penetration by blowing from one-third to two-thirds of the bath depth (R. 10,995; Defendant's main brief, p. 130) and, therefore, following the teachings of Schwarz. (R. 13,819.) Defendant also contends that the term "deep penetration" as used in the Suess patent means a "practically negligible penetration." (Defendant's reply brief, p. 98.) Thus, on the [56] one hand, at least one witness for plaintiffs sees the avoidance of deep penetration as any penetration less than 90% of the bath depth, while, on the other hand, defendant sees the avoidance of deep penetration as literal surface blowing without any penetration of the bath at all. (Defendant's reply brief, p. 99.)

(3) Nonobviousness of the invention

It appears to this Court that penetration of the bath by the jet within the limits taught by the specification of the patent in suit is the reason for the success of the Linz process. Such penetration results in a steelmaking operation that avoids the problems of refractory damage and excessive phosphorus in the finished steel

which had rendered the prior art teachings commercially inoperable. It also appears to this Court that blowing so as to achieve such a limited degree of penetration was unobvious to persons skilled in the art prior to 1950. Indeed, by 1950 there would have been good reason for persons skilled in the art to despair of finding a successful oxygen blowing process for steelmaking in light of the failures of the prior art teachings and the numerous unsuccessful experiments with oxygen blowing conducted during many years prior thereto. On the one hand, a series of patents going back as far as the Robert Patent (DX 61) in 1888 had taught literal surface blowing with only negligible penetration of the bath by a jet or jets and produced no practical results. On the other hand, the processes of the Schwarz, Miles and Potts patents, which taught deep blowing, were also commercially inoperable. Therefore, the entire approach to steelmaking by blowing oxygen from above onto a bath might well have seemed unfruitful in light of the failures of both surface blowing and [57] deep blowing. The success of the patentees appears to have been the result of using an intermediate degree of penetration between surface blowing and deep blowing.

A significant difference between the teachings of the specification of the patent in suit and the Schwarz and Miles patents is that the patent in suit places a maximum limit on penetration with reference to the formation of a fluid slag. The Schwarz and Miles patents contain no such teaching, and, therefore, a steelmaker following the teachings of Schwarz and Miles might well blow oxygen deeper into the bath than the maximum limit permitted by the teachings of the patent in suit and thereby fail to obtain the fluid slag necessary for adequate phosphorus and sulphur removal. Such maximum limit on penetration appears to this Court to be the real gist of the invention by the patentees (see testimony of Dr. Trenkler, R. 11,904-05), and seems to have been unobvious, in view of the apparent failure of steelmakers to observe such limit of penetration following the teachings of the Schwarz and Miles patents.

(4) Nonobviousness of the claims

It is not clear that the actual invention of the Linz process is incorporated in the claims of the patent in suit. It is true that the Rinesch and Hauttmann affidavits in 1957 attributed a causal connection between the avoidance of deep penetration and the existence of the features of the patent claims, including a localized reaction zone, the avoidance of material agitation of the bath and a circulation caused by chemical reactions. For example, Dr. Rinesch stated (DX 116, p. 7):

> [58] "The important feature of the invention resides in controlling the force of the oxygen jet vertically impinging on the bath surface to cause a limited center of reaction to be created in the surface layer and to avoid deep penetration into the bath, whereby an automatic circulatory movement is obtained in the converter vessel, and the entire charge is refined by the oxygen molten metal reactions in the limited center and the slag-metal reactions in the bath surrounding the reaction center."

However, it is a serious question whether persons skilled in the art of steelmaking in 1950 would have un-

derstood the features of the claims of the patent in suit as depending upon the avoidance of deep penetration for their existence. In other words, it is questionable whether the claims of the patent in suit have any clear connection with what appears to this Court to be the actual invention by the patentees. Such issue, however, arises under Section 112 rather than Section 103 and will be discussed below. As already noted, the *Graham* case, *supra,* 383 U. S. 1, at p. 17, makes clear that the issue under Section 103 requires an analysis of the differences between the prior art and the *claims* at issue, since only the subject matter of the claims constitutes "subject matter sought to be patented" within the meaning of Section 103. The issue under Section 103 is the obviousness of the subject matter of the claims to persons skilled in the art and not the obviousness of unclaimed subject matter disclosed by the specification, which constitutes a dedication to the public. *Edward Miller & Co. v. Bridgeport Brass Co.,* 104 U. S. 350, 352 (1881).

First of all, it is doubtful whether the claim of vertical blowing would have been obvious to steelmakers in 1950 in view of the unspecific teaching of Schwarz on the point and the recommendation of Miles to blow at an angle of between 30 and 75 [59] degrees.

The claim of blowing "onto and below the surface of the bath at the central portion thereof, to an extent to avoid material agitation of the bath by the oxygen stream" is almost certainly nonobvious in view of Miles' teaching that when the oxygen jet was blown below the surface, the jet agitated the bath. Further, it is defendant's position that agitation of the bath in McLouth's

steelmaking operation is largely the result of the mechanical action of the oxygen jet. Plaintiffs contend that material agitation of the bath is agitation sufficient to overcome the alleged down in center circulation of the bath created by chemical reactions. (E.g., main brief, p. 191.) Such a concept would certainly not have been obvious to steelmakers in 1950, since at that time the very idea of a down in center circulation caused by chemical reactions was not generally known to persons skilled in the art. Indeed, the concept of a down in center circulation of the bath caused by chemical reactions is not a well recognized and accepted phenomenon, even today. There is disagreement in the expert testimony in this litigation as to its existence; it is not clearly taught by the specification of the patent in suit; and other patents, notably the Cuscoleca and Walker patents, advance alternative theories of circulation relating to chemical reactions. (DX 68.) But if a down in center circulation caused by chemical reaction is itself not necessarily obvious to steelmakers even today, it is difficult to understand how the idea of avoiding a material agitation of the bath by a jet which would overcome such a circulation would be obvious.

The language in the claims of the patent in suit concerning the avoidance of material agitation was an apparent [60] effort by the applicants to distinguish the prior art Miles patent, which taught that a jet agitates the bath. At the time this feature of the patent claims was first presented in June of 1957, previous claims had been rejected as unpatentable over Miles. There was, therefore, the necessity for presenting new claims which in some manner would distinguish the Miles patent in

order to obtain a patent grant. It is significant also to note that the patent itself issued less than two months after the final claims including language referring to the avoidance of material agitation were submitted to the Patent Office. Previous to June, 1957, no reference had been made to the concept of avoidance of material agitation by the oxygen stream anywhere in the file wrapper history of the patent insuit. Incidentally, the concept is not mentioned in any of the foreign patents on the Linz process granted to Dr. Suess. (DX 83.)

The "localized reaction zone spaced a substantial distance from the refractory lining" and the "high temperature" in such reaction zone are features of the claims which this Court considers anticipated by the Schwarz and Miles patents and therefore certainly obvious to persons skilled in the art. The Schwarz patent states:

> ". . . the reaction between oxygen and iron or iron-accompanying substances with the phenomena resulting therefrom, namely local overheating and the accumulation of ferrous oxide, takes place in the center of the steel bath and therefore the walls of the vessel are not substantially attacked." (DX 61, Schwarz, pp. 4-5.)

Miles' teaching that "the source of chemical oxidation reaction is located within the bath at a good distance from the refractory lining" implies a localized reaction zone, and, further, Miles' teaching of blowing oxidizable elements in with the jet to [61] "increase the temperature locally where the jet strikes the bath so as to bring about the oxidizing action more rapidly" suggests a localized reaction zone with higher temperatures than the rest of the bath. (DX 61, Miles, pp. 3 and 15.)

The nonobviousness of the claim of a circulatory movement in the molten metal produced by chemical reactions has already been discussed in connection with the claim of avoidance of material agitation. It seems clear to this Court that such a reaction-induced circulation would not have been obvious to steelmakers in 1950, especially in view of the teaching of the Miles patent that the action of the jet agitates and circulates the bath, and also in view of the disagreement among the expert witnesses at the trial, even in 1964, whether such a reaction-induced circulation in fact exists.

Defendant in effect concedes the nonobviousness of the subject matter of the claims of the patent in suit by repeatedly contending in its opening statement, its briefs after trial and its final arguments that the process of the claims does not exist, or, in other words, that there is no such thing in steelmaking as a reaction-induced circulation or the avoidance of material agitation of the bath by the oxygen stream.

On opening statement, counsel for defendant stated:

> "They [Schwarz and Miles] weren't compelled to resort to the subterfuges of the patent in suit. They didn't have any absurdities about the avoidance of material agitation. So there are differences between the patent in suit and Schwarz and Miles.
>
> "But to the extent that the patent in suit departs from Schwarz and Miles it is pure phoney, non-practiced, non-known, in any commercial operation in the world." (R. 143-44.)

[62] Defendant's main brief after trial states:

"The patent, in teaching a down-in-the-center circulation, taught something which does not exist. And the claims of the patent, in calling for a reaction-induced circulation, call for something else which does not exist." (P. 189; see also 177, 210-11.)

Similarly, defendant's reply brief states:

"The reaction-induced circulation comes into this case only through the claims of the patent in suit, and, in fact, does *not* exist." (P. 40. Emphasis is in original.)

Further, defendant's proposed finding of fact No. 83 requests the Court to find that "the claims in requiring that circulation be produced by chemical reaction, call for something which does not exist."

On final argument, the following colloquy occurred:

"*The Court*: Of course, if the process is as the patent claims to be, then it would be a patentable invention; there wouldn't be any question about that, would there?

"[*Counsel for Defendant*]: Well, if they had a circulation which was induced by chemical reaction, and if they had a circulation down in the center, they would have something that no one has ever heard of before; and so conceivably that would be an invention. Its application to the making of steel is something else again. I don't know whether it would work or not. But it's something that no one has ever faced, because they can't do it.

"*The Court*: Well, I mean, if the claims were supported and taught by the specifications, it would be a patentable invention, would it not?

"[*Counsel for Defendant*]: If the claims were supported in the sense that there was such a circulation, it would certainly be entirely new. It is something of which the world has never heard, and something which, except for the testimony in this case, there is no support anywhere in any scientific annal of which anybody in this case has ever heard. Plaintiffs have been challenged to bring forward some substantiation, and they haven't come forward with an iota." (R. 13,511-12; see also R. 13,711.)

[63] Assuming defendant is correct in contending that the process as claimed in the patent in suit does not exist in actual steelmaking operations, it follows that the process as claimed could not have been obvious to persons skilled in the art.

(5) CONCLUSION

In short, this Court concludes that defendant has not sustained its burden of proving that the subject matter of the claims of the patent in suit would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. In reaching such conclusion, the Court draws a clear distinction between the subject matter of the claims and the subject matter of the specification, also found unobvious. The specification discloses the gist of the invention of the patentees, to avoid blowing deeply so as to assure the formation of an early fluid slag. The long-standing need for such an in-

vention; the many unsuccessful attempts to solve the problem in the years prior to 1949; the significant advantages of the invention; and the enthusiastic reaction of the industry to the invention after a period of initial skepticism, all clearly indicate that the invention by the patentees, the Linz process, was not obvious to persons skilled in the art.

It should be noted that the defendant's position on the issue of obviousness has been equivocal throughout this litigation. Although the pretrial order states an issue in the language of Section 103, the opening statements and briefs of defendant after trial never expressly referred to Section 103. Instead, defendant contended vaguely that the patent in suit was invalid for lack of invention over the Schwarz and Miles patents, a confusing contention which could invoke defenses under either Section [64] 102 or Section 103. On closing arguments, defendant did expressly rely on Section 103 (R. 13,410), but practically conceded nonobviousness of the subject matter of the claims of the patent in suit, as already noted. (R. 13,511-12.)

C. Inventorship

Defendant in this case has also raised an issue that the patentees of the patent in suit did not themselves invent the subject matter sought to be patented, but rather that the invention was entirely disclosed to the patentees by Dr. Durrer and Dr. Hellbruegge. Such a defense arises under 35 U.S.C. §102(f), which provides that a person shall not be entitled to a patent if "he did not himself invent the subject matter sought to be patented." As previously noted, Section 103 clarifies Sec-

tion 102 by adding a further requirement of nonobviousness for patentability, even if the invention is not "identically disclosed or described" to the patentee by someone else. Thus Section 103 makes clear that the test as to whether the patentees themselves invented the subject matter is whether it was "identically disclosed or described" to them by Dr. Durrer and Dr. Hellbruegge.

Section 282 of 35 U.S.C. places the burden of proof as to this issue on the defendant, as in all issues concerning the validity of the patent in suit. Defendant's burden of proving that the patentees were not the true inventors is heavy and requires evidence which is convincing perhaps even beyond a reasonable doubt. *Becton-Dickinson & Co. v. Robert P. Scherer Corp., et al.*, 106 F. Supp. 665 (E.D. Mich. 1952), affirmed 211 F. 2d 835; *Manton-Gaulin Mfg. Co. v. Dairy Machinery & Construction Co.*, [65] *Inc.*, 238 F. 210 (D. Conn. 1916), affirmed 247 F. 317; *Protector Last Reinforcing Co. v. John Pell & Son, Inc.*, 204 F. 453 (D. N.J. 1913). As Judge Tuttle of this District stated in *Fruehauf Trailer Co. v. Highway Trailer Co.*, 54 F. 2d 691, 702 (E.D. Mich. 1931), affirmed 67 F. 2d 558 (CCA 6, 1933):

> "To take up first the testimony of Learman relating to the first Borst patent coupling device particularly, tending to show that Borst stole his notions, I will say that we are now in a branch of the law, patent law, which is very clear and well settled. Any claim of that kind tending to destroy the originality of the patentee, before it can be entertained by the court, must be shown by very convincing and strong evidence. It is well recognized that the memory of man is not sufficient to meet

that test. There must be something more tangible. We look for records that fix dates, a very definite sort of thing to tie to . . ."

Incidentally, defendant does not appear to dispute the severity of its burden of proof on this issue. Thus, the issue with respect to inventorship is whether defendant has proved by evidence that is convincing beyond a reasonable doubt that the patentees did not themselves invent the subject matter of the patent in suit because the subject matter was identically disclosed to them by Dr. Durrer and Dr. Hellbruegge. To resolve this issue, the Court is obliged to consider evidence concerning the teachings and disclosures of Dr. Durrer and Dr. Hellbruegge to the patentees, the results achieved in steelmaking by Dr. Durrer, Dr. Hellbruegge and the patentees, and also relevant acts and statements by Dr. Durrer and Dr. Hellbruegge concerning oxygen steelmaking.

(1) THE TEACHINGS OF DR. DURRER AND DR. HELLBRUEGGE AND THE PATENTEES

Dr. Durrer and Dr. Hellbruegge were distinguished scientists and steelmakers particularly concerned with the use of [66] oxygen in steelmaking. Dr. Durrer had been an advocate of the use of pure oxygen in steelmaking as early as the 1930's, and both Dr. Durrer and Dr. Hellbruegge had had considerable independent experience in steelmaking by 1948. In the spring of that year, they commenced experiments at the Von Roll Steel Works in Gerlafingen, Switzerland, involving the use of oxygen blown from above into a molten pig iron bath. Such experiments continued at least intermittently

throughout 1948 and the spring of 1949. During that time, Dr. Durrer and Dr. Hellbruegge were in limited contact with Dr. Trenkler and Dr. Suess, two of the patentees, concerning the experiments at Gerlafingen. Dr. Hellbruegge in particular was enthusiastic about the results achieved, and notified Dr. Trenkler in April of 1949 that "We are now working for production." (DX 21 B, p. 1; see also pp. 11,817-18.) The process employed by Dr. Durrer and Dr. Hellbruegge at Gerlafingen was described in an article written by Dr. Hellbruegge appearing in 1950 in the magazine *Stahl und Eisen* (DX 61) and also by the testimony at trial of Dr. Durrer and Dr. Hellbruegge, as well as the patentees. It is admitted by defendant that the practice of Dr. Durrer and Dr. Hellbruegge at Gerlafingen was essentially indistinguishable from the teachings of the Schwarz patent. (E.g. R. 13,503.) In general, the practice at Gerlafingen consisted of blowing pure oxygen in a single jet initially at an angle, but in later tests, vertically down into the pig iron bath so as to achieve a deep penetration of the bath by the jet. Thus Dr. Hellbruegge states in his article (p. 5):

"The blowing onto the bath must not be done with too little pressure, as otherwise there will be only a surface reaction. This means that too much oxygen is lost. The refining takes too long a time and the iron content of the slag will be too high."

[67] Dr. Hellbruegge further states (p. 7):

"The pressure of the oxygen jet must be sufficiently strong to cause the jet to penetrate into the bath, especially at the beginning and toward the end of the melt."

Dr. Hellbruegge testified this was still his thinking at the time of trial (R. 4909-11; 4670). Further, in a letter written in 1952, he stated:

> "The oxygen process, as introduced at the time in Linz by Gerlafingen within the Study Group, does not in my opinion circumvent the Schwarz patent, since there is not simply top blowing, but the jet must penetrate deep, even though it need not be supersonic speed." (DX 89B (25), p. 4.)

At trial, Dr. Hellbruegge affirmed this statement as his thinking at the time. (R. 4667.)

Dr. Durrer testified at the trial that the Schwarz patent contained his ideas. (R. 5101.) Further, in the memorandum prepared by Dr. Hellbruegge of a meeting in Solothurn, Switzerland, held on June 9, 1949, it is stated:

> "In the case of Prof. Schwarz's patent applications there is in all probability concerned in accordance with Dr. Durrer's statement, the theft of intellectual property." (PX 301B, p. 4.)

This memorandum further indicates Dr. Durrer's opinion that the Schwarz patent resulted from discussions that Dr. Durrer himself had had with the Brassert Company in the 1930's. In any event, Dr. Durrer affirmed the similarity of his teachings to those of the Schwarz patent, regardless whether Dr. Durrer himself was the true inventor of the process claimed in the Schwarz patent. (R. 5100-01.)

Dr. Trenkler testified that Dr. Durrer and Dr. Hellbruegge taught deep penetration of the bath by the jet. (R. 11,950.) Dr. Hauttmann testified that the Durrer method corresponded [68] to that of Schwarz. (R. 2555-

56.) Defendant has admitted in its opening statement, final arguments and briefs after trial that Dr. Durrer and Dr. Hellbruegge taught deep blowing.[5]

Also, with regard to penetration, Dr. Trenkler testified that Dr. Durrer and Dr. Hellbruegge taught going as close to the bath as possible with the nozzle. (R. 11,805, 11,870, 11,873, 11,894 11,931, 11,941.) The effect of such teaching would be, of course, to increase the depth of penetration of the bath by the oxygen jet.

In contrast to the teachings of Dr. Durrer and Dr. Hellbruegge as to the necessity of a deep penetration of the bath by the oxygen jet, the patentees taught the avoidance of deep penetration as the gist of their invention. The patent itself expressly teaches the avoidance of deep penetration at column 3, lines 46 and 74; col. 4, line 70; and col. 9, line 18. Also, the Rinesch affidavit (DX 116) states that "A satisfactory refining operation could be obtained as long as the oxygen jet does not penetrate deeply into the bath." The Hauttmann affidavit (DX 117) makes essentially the same statement. And Dr. Trenkler testified as to the importance of the avoidance of deep penetration in the process of the patent in suit. (R. 11,942 and 11,904.) Further, Dr. Suess was also apparently aware of the importance of avoiding deep penetration, as indicated by the claims of his original Austrian application (PX 2C) and the first four claims of the United States continuation-in-part

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5. See, for example, main brief p. 227 stating that the process of the patent is the process taught by Dr. Durrer, and also p. 152 ff. stating that the avoidance of deep penetration is a fiction in the patent suit. See also reply brief p. 42 stating that the teachings of Schwarz and Durrer are the same and both entailed deep blowing.

application. (PX 2A.) Thus [69] the teachings of Dr. Durrer and Dr. Hellbruegge that a deep penetration of the bath by the jet is essential are in contrast to the teachings of all four of the patentees that deep penetration must be avoided.

A further significant teaching of Dr. Durrer and Dr. Hellbruegge concerns the iron content of the slag. Apparently Dr. Durrer and Dr. Hellbruegge were concerned in their steelmaking experiments in keeping the iron content of the slag as low as possible. In the *Stahl und Eisen* article (DX 61, p. 13), Dr. Hellbruegge stated that when oxygen was blown with too small a pressure, the iron loss to the slag was too high. He also stated at p. 9 that in the satisfactory heats at Gerlafingen, the iron content of the slag varied between 9% and 11%. At trial, Dr. Hellbruegge testified that he wanted to keep the iron content of the slag as low as possible, but "unfortunately" he could not get it any lower than 9% in the Gerlafingen tests. (R. 4926.)

Dr. Trenkler testified that according to the teachings of Dr. Durrer and Dr. Hellbruegge, "the oxygen jet has to penetrate into the lower regions of the bath so that a corresponding bath movement by the oxygen stream will be insured and a low iron content of the slag can be obtained." (R. 11,894.)

In contrast, the patentees were not primarily concerned with keeping a low iron content in the slag during their steelmaking experiments. The Rinesch affidavit (DX 116, p. 4) notes that in the satisfactory June 25 series of tests at Linz "the iron content of the slag increased to an average of 14 to 20%." The patent itself teaches at col. 5, line 60, to col. 6, line 51, that a

certain amount of oxidized iron in the slag is essential for the formation of the early fluid slag which results in an [70] accelerated rate of phosphorous removal from the bath. At col. 6, line 44, the patent approves an iron content of from 9% to 18% in the slag "with generally higher FeO content in the slag at higher phosphorus contents in the pig iron." In other words, according to the teachings of the patent in suit, a higher iron content in the slag than that approved by Dr. Hellbruegge is deemed essential for adequate phosphorus removal from the bath. Apparently Dr. Durrer and Dr. Hellbruegge, unlike the patentees, were more concerned with keeping down the iron content of the slag than with lowering the phosphorus content of the bath to desirable levels for high quality steel.

(2) The disclosures of Dr. Durrer and Dr. Hellbruegge to the patentees

On May 12, 1949, Dr. Trenkler, one of the patentees, made a visit to Gerlafingen, Switzerland, to acquaint himself with the work which Dr. Durrer and Dr. Hellbruegge had been carrying on. While at Gerlafingen, Dr. Trenkler had "thorough discussions" (R. 11,805) with Dr. Durrer and Dr. Hellbruegge concerning their work and received detailed information about the Gerlafingen operation which he later incorporated into a memo (DX 11B) dated May 15, 1949. This memo establishes the disclosure to Dr. Trenkler of:

1. The use of pure oxygen.
2. The use of a blowing method of steelmaking without additional heating of the bath.
3. Use of a 2-ton Bessemer converter.

4. Vertical blowing.
5. The use of an 8 mm. nozzle.
6. Seven atmospheres of blowing pressure.

[71]7. A scrap accumulation of 50% when Thomas pig iron is used and a 30% scrap accumulation with steel-pig.

8. The cost of oxygen as corresponding with air costs of a standard operation.

9. The quality of the steel produced as being "substantially more favorable in regard to impact tenacity and aging-impact tenacity than the Belgian Thomas iron with which it was compared."

With regard to nozzle bath distance, Dr. Trenkler testified at the trial that he was not given any numerical distance (R. 11,806-08, 11,931) despite his "thorough" discussions with Dr. Durrer and Dr. Hellbruegge. Dr. Trenkler testified that he was told only to go as close to the bath as possible with the nozzle (R. 11,805, 11,870, 11,873, 11,931, 11,941). On the other hand, Dr. Durrer and Dr. Hellbruegge testified at the trial that they mentioned to Dr. Trenkler a nozzle bath distance of 20 centimeters (roughly 8 inches). (R. 4593, 4621, 4652, 4928, 5022.) There appears from the record good reason to accept the testimony of Dr. Trenkler on this point over that of Dr. Durrer and Dr. Hellbruegge. In the only contemporary statement on the point, the Trenkler memo DX 11 B dated May 15, 1949, there was no mention of any nozzle bath distance disclosed by Dr. Durrer and Dr. Hellbruegge, even though there was no reason to omit such information from the memo at that

time if it had been given. Further, the evidence shows that the men at Linz wanted to follow the teachings of Dr. Durrer and Dr. Hellbruegge as well as Schwarz and Miles in the tests beginning June 17, 1949. (Dr. Hauttmann, R. 2659-60.) Dr. Trenkler noted in his memo DX 11B: "It is absolutely essential that we examine the relationships in blowing our steel-pig with oxygen by thorough testing." Yet Dr. Trenkler used a nozzle bath [72] distance of ten centimeters (roughly 4 inches) in the June 17th tests following the teachings of Dr. Durrer and Dr. Hellbruegge and thus went even closer to the bath with the nozzle than Dr. Durrer had done at Gerlafingen. It seems unlikely that Dr. Trenkler would have departed from the teachings of Dr. Durrer and Dr. Hellbruegge in this one particular in a series of tests which were intended to follow the teachings of Dr. Durrer and Dr. Hellbruegge. Significantly, in the June 17th series of tests, Dr. Trenkler got even poorer results with regard to phosphorus removal and refractory damage than Dr. Durrer and Dr. Hellbruegge had gotten at Gerlafingen, apparently because Dr. Trenkler placed the nozzle 10 centimeters closer to the bath. (See *infra* II C(3).) Thus, this Court finds as a fact that Dr. Trenkler was given no numerical nozzle bath distance by Dr. Durrer and Dr. Hellbruegge.

With respect to the type of nozzle to be used, Dr. Trenkler testified that he was told to use a water-cooled copper Laval nozzle. (R. 11,835.) There is no evidence in the record to the contrary.

It can, therefore, be seen that Dr. Durrer and Dr. Hellbruegge disclosed to the patentees details of a steel-making operation very similar to the operation in which

satisfactory low phosphorus steel was produced for the first time in the Linz tests on June 25, 1949. Indeed, Dr. Trenkler testified (R. 11,905) that the avoidance of deep blowing in the process at Linz was the only difference from the process of deep blowing at Gerlafingen. In like manner, Dr. Hauttmann testifed that the only changes in operating procedure made by the patentees from the June 17th tests following Dr. Durrer's teachings to the June 25th tests following the patentees' own ideas, were the change from a Laval [73] nozzle to a normal cylindrical nozzle and an increase in the nozzle bath distance from 10 centimeters to 15 centimeters. (R. 2665, 2246, 2256.) Plaintiffs also admitted on final arguments that the only mechanical changes in method from the teachings and disclosures of Dr. Durrer and Dr. Hellbruegge were the change from a Laval to a normal nozzle and an increase in the nozzle bath distance. (R. 13,184-87.)

Plaintiffs contend that Dr. Durrer and Dr. Hellbruegge did *not* disclose the concept of a reduced impact pressure of the jet on the bath so as to avoid deep penetration. Such avoidance of deep penetration, according to the plaintiffs, is "the new concept, the new mental approach" of the patentees. (R. 13,184-87.) It is not disputed that the change in nozzle type and nozzle bath distance by the patentees would have had the effect of reducing impact pressure and therefore reducing the depth of penetration. Whether such a reduction in penetration by the patentees should be considered significant for patent purposes could only be determined by a comparison of the actual results achieved by the tests at Gerlafingen and Linz. If there were no significant

differences in the quality of steel produced, the difference in the degree of penetration of the bath by the jet would have no significance, and this Court would be forced to conclude that the process at Linz was in fact disclosed in its entirety by Dr. Durrer and Dr. Hellbruegge so as to establish a defense of non-inventorship by the patentees in this case. However, analyses of the steel produced in a number of experiments at Gerlafingen and at Linz, as listed in the *Stahl und Eisen* article by Dr. Hellbruegge (DX 61, p. 11) and a work sheet (DX 116A) attached to the Rinesch affidavit (DX 116), indicate clearly that the results of the Linz tests [74] beginning June 25th were superior to those at Gerlafingen.

(3) Comparison of the Tests At Gerlafingen, Switzerland, and Linz, Austria

In the Gerlafingen tests of record, the steel produced had a relatively high phosphorus content with only 2 of 20 heats having a phosphorus content of less than .03%. The Linz June 17th tests, following Dr. Durrer's teachings but blowing even closer to the bath than Dr. Durrer had done at Gerlafingen, had an even higher phosphorous content in the steel produced, with none of the 6 heats containing less than .07% phosphorus. On the other hand, the June 25th tests at Linz obtained satisfactory phosphorus removal, with 6 of 11 heats containing below .03% phosphorus.

The Court has prepared a series of charts based on information taken from DX 61 and DX 116A concerning phosphorus content in the steel produced in the experi-

ments at Gerlafingen and Linz.[6] [75] Specifically, Chart 4, prepared by the Court, is a comparison by percentages of the heats run at Gerlafingen and at Linz with regard to the phosphorus content of the steel produced. It is

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6. Chart 1 shows what percentage of the 20 heats at Gerlafingen reported in Dr. Hellbruegge's *Stahl und Eisen* article were below certain levels of phosphorus in the final steel produced:

CHART I	*Gerlafingen tests*
20 of 20 heats below	.1 % P— 100%
18 of 20 " "	.09 % P— 90%
17 of 20 " "	.08 % P— 85%
12 of 20 " "	.07 % P— 60%
10 of 20 " "	.06 % P— 50%
7 of 20 " "	.05 % P— 35%
3 of 20 " "	.04 % P— 15%
2 of 20 " "	.03 % P— 10%
None of 20 " "	.02 % P— 0%

Chart 2 gives the same information with respect to the 6 heats of the June 17th series of tests at Linz attempting to follow the teachings of Dr. Durrer. The chart is based on two different measurements of phosphorus content in the bath, the first being an analysis of the phosphorus content of the final steel in the converter, and the second being an analysis of the phosphorus content of the steel during the pouring from the ladle into the ingot:

CHART 2 — June 17th tests at Linz

In converter	*During pouring*
2 of 6 heats below .1 — 33%	3 below .1 — 50%
1 of 6 heats below .09 — 17%	2 below .09 — 33%
1 of 6 heats below .08 — 17%	1 below .08 — 17%
None of 6 heats " .07 — 0%	None below .07 — 0%

Chart 3 gives the same information with respect to the heats reported in DX 116A from the June 25th series of tests at Linz, departing from the teachings of Dr.

important to emphasize once again at this point the desirability of a low phorphorus content, i.e., no more than .03% for satisfactory high quality steel. Higher concentrations of phosphorus tend to harden and brittle the

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Durrer by reducing impact pressure and consequently reducing penetration. An analysis of the phosphorus content of the final steel in the converter was reported in 10 heats of the June 25th series of tests. However, the phosphorus content of the steel poured from the ladle into the ingot is reported in 11 heats of this June 25th series of tests at Linz:

CHART 3 — June 25th tests at Linz

In converter	*During pouring*
10 of 10 heats below .07 — 100%	10 of 11 heats below .07 — 91%
8 of 10 heats below .06 — 80%	10 of 11 heats below .06 — 91%
6 of 10 heats below .05 — 60%	10 of 11 heats below .05 — 91%
5 of 10 heats below .04 — 50%	8 of 11 heats below .04 — 73%
4 of 10 heats below .03 — 40%	6 of 11 heats below .03 — 55%
None of 10 heats " .02 — 0%	1 of 11 heats below .02 — 9%

Significantly, in the June 25th series of tests, heats having the greatest nozzle bath distance, and, therefore, the lowest impact pressure, generally had the lowest phosphorus content in the steel produced.

CHART 4

% of Heats Containing Below	*Gerlafingen*	*Durrer Method (Linz June 17th)*		*Patentees' Method (Linz June 25th)*	
		Converter	*Pouring*	*Converter*	*Pouring*
.1 P	100%	33%	50%	100%	100%
.09 P	90%	17%	33%	100%	100%
.08 P	85%	17%	17%	100%	100%
.07 P	60%	0%	0%	100%	91%
.06 P	50%	0%	0%	80%	91%
.05 P	35%	0%	0%	60%	91%
.04 P	15%	0%	0%	50%	73%
.03 P	10%	0%	0%	40%	55%
.02 P	0%	0%	0%	0%	9%

steel and therefore limit its usefulness for many purposes. (Dr. Chipman, R. 235.) Dr. Trenkler also testified that "high phosphorus content excludes the use of the steel for all, almost all, qualities of thin sheets and deep drawing quality sheets." (R. 11,929.) Chart 4 illustrates that **[76]** the June 25th series of tests at Linz had significantly lower phosphorus content in the steel produced than either the previous tests at Gerlafingen or the June 17th series of tests at Linz. The striking disparities in the results of these three series of tests appears to this Court to be attributable solely to differences of impact pressures caused by the variation in the type of nozzle used or nozzle bath distance, or both.

Further, the available information with respect to the iron content of the slag in the tests at Gerlafingen and at Linz indicates an inverse correlation between the iron content of the slag and the phosphorus content of the steel produced. In the Gerlafingen tests, according to Dr. Hellbruegge, the iron content of the slag varied between 9% and 11%. (DX 61, *Stahl und Eisen* article, p. 9; R. 4926.) In the Linz June 17th series of tests involving even deeper penetration than achieved at Gerlafingen, the iron content of the slag varied from 6.7% to 9.8% **[77]** (DX 116A.) On the other hand, in the June 25th tests, the iron content of the slag varied from 9.6% to 33.9% with 9 of 11 heats reported being roughly in the range of 11% to 20%. (DX 116A.)

Chart 5, also prepared by the Court, illustrates an inverse correlation between the iron content of the slag and the phosphorus content of the steel in the tests at Gerlafingen and at Linz, or, in other words, illustrating that the higher the iron content of the slag becomes, at

least within the limit of the tests reported, the lower the phosphorus content of the steel tends to be.[7]

The Rinesch affidavit explains this correlation by pointing out that a slag with high iron content "forms with limestone a very fluid, lime-ferrite slag which absorbs the phorphorous as shown by the fact that it contains an average of 1.2 to 1.8% P_2O_5, as compared with 0.18% to 0.3% P_2O_5 in the slag which was formed by the deeply penetrating oxygen stream." (DX 116, p. 4.) The Rinesch affidavit also states that with deep penetration "the slag was unable to absorb FeO which, in its turn, is needed for **[78]** good dephosphorization." (P. 3.) Dr. Trenkler testified that "when you blow deeply the formation of the basic slag that you need for the phosphorus removal occurs too late." (R. 11,942; see also Dr. Chipman, R. 442-44.) The patent itself also teaches the necessity of an early fluid slag rich in oxides such as FeO for adequate phosphorus removal. (Col. 5, line 60, to col. 6, line 51.) Additionally, Dr. Chipman testified in detail (R. 583-87 and 606) concerning the chemistry of phosphorus removal in the Linz process. Briefly, he testi-

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7. *CHART 5*

Tests	*Iron in Slag*	*Phosphorus in Steel*	
Gerlafingen	9 —11%	— 35% of heats below	.05% P
		— 10% of " "	.03% P
Linz, June 17	6.7— 9.8%	— 0% of heats below	.05% P
Linz, June 25	9.6—33.9%	— 60% of heats in converter below	.05% P
	(mainly 11 —20%)	40% of heats in converter below	.03% P
		91% of heats during pouring below	.05% P
		55% of heats during pouring below	.03% P

fied that phosphorus is removed from the bath into the slag by slag-metal reactions written as follows in PX 151:

$$2\,P\ (\text{in bath}) + 5\,FeO\ (\text{in slag}) + 3\,CaO\ (\text{in slag}) = 3\,CaO{\cdot}P_2O_5 + 5\,Fe$$

$$2\,P\ (\text{in bath}) + 5\,O\ (\text{in bath}) + 3\,CaO\ (\text{in slag}) = 3\,CaO{\cdot}P_2O_5$$

Dr. Chipman illustrated (PX 152 and 153) the effect of penetration on slag formation. The diagram in PX 152 indicated that the avoidance of deep penetration results in the formation of a slag with high FeO content. PX 153 illustrates, on the other hand, that deeper penetration puts oxygen into the metal rather than the slag, which, therefore, has a low FeO content.

Another significant difference in the tests at Gerlafingen and at Linz is the use of an afterblow in the Gerlafingen tests to remove phosphorus. Dr. Hellbruegge testified that in the Gerlafingen tests, he had to have an afterblow to get rid of phosphorus. (R. 4915; see also R. 4929-30; DX 61, *Stahl und Eisen* article, pages 9 and 13.)

The patentees, on the other hand, apparently did not use an afterblow in the Linz tests; at least there is no evidence in this record that an afterblow was ever used at Linz. [79] However, the patent in col. 6, lines 16 to 25, indicates that no afterblow is required to remove phosphorus to the desired level since, according to the process disclosed by the patent in suit, "final phosphorus contents not higher than about 0.025% and as low as 0.010% are obtained by the time the carbon end point is reached with only a single slagging operation." Further, Dr. Trenkler testified that "you have an afterblowing time only if you blow deeply." (R. 11,948.)

The absence of an afterblow at Linz is quite significant since even without an afterblow to remove phosphorus as at Gerlafingen, the phosphorus content of the steel produced in the June 25th series of tests at Linz was still lower than in the steel produced at Gerlafingen. This difference in result is apparently explained by a different order of chemical reaction when deep penetration was avoided. Thus, in the Linz tests, phosphorus was apparently removed from the bath at the same time as carbon and not afterwards, as at Gerlafingen. As Dr. Trenkler testified: "Owing to this type of blowing to the upper regions of the bath, we have an essentially earlier dissolution of the lime, a higher Fe content in the slag, and thereby a faster and better dephosphorization." (R. 11,904.) As already noted, the patent in suit teaches this phenomenon at col. 6, lines 16 to 25. The earlier removal of phosphorus in the Linz June 25th series of tests to even lower levels than in the Gerlafingen tests, and without the need for an afterblow, indicates strongly an entirely different steelmaking process taking place in the Linz June 25th series of tests than at Gerlafingen, despite a seemingly minor change in the operating procedures.

[80] There is a further significant contrast between the tests at Gerlafingen and the June 25th series of tests at Linz concerning refractory damage. There is a dispute in the evidence as to whether at Gerlafingen problems of refractory damage had been solved. Dr. Hellbruegge in his *Stahl und Eisen* article (DX 61, p. 14) stated that in the Gerlafingen operations: "There are no difficulties

with respect to the durability of the nozzle nor to that of the converter." On the other hand, Dr. Trenkler testified that he was told at Gerlafingen that Dr. Durrer and Dr. Hellbruegge had initially encountered difficulties concerning an insufficient life of the nozzle and an extremely short life of the refractory lining lasting only one to two heats. According to Dr. Trenkler: "The transition to the bent lance blowing vertically from above remedied the difficulties consisting in the burning of the nozzle— . . . and the difficulties concerning the refractory lining became smaller without ceasing altogether." (R. 11,838-39.) Dr. Trenkler also testified that "The insufficient life of the refractory lining of the converter" (R. 11,929) was a defect in the Gerlafingen operation. The Rinesch affidavit states that in the June 17, 1949, series of tests at Linz attempting to follow the teachings of Dr. Durrer and Dr. Hellbruegge, "The lining of the converter was eroded quickly so that considerable quantities of MgO were released from the lining." (DX 116, p. 3.) Further, the work sheet for the Linz tests (DX 116A) notes that in the June 17th series of tests, the converter lining was strongly eroded. The Hauttmann affidavit (DX 117) and the testimony of Dr. Trenkler (R. 11,901-04) also confirmed the existence of refractory damage in the June 17th series of tests. The refractory damage experienced in the June 17th series of [81] tests at Linz following the teachings of Dr. Durrer and Dr. Hellbruegge gives some reason to accept the testimony of Dr. Trenkler that problems of refractory damage had not been completely solved at Gerlafingen. Dr. Trenkler testified that the damage to the converter in the June 17th series of tests influenced a

series of tests beginning June 22nd so unfavorably because of the presence of MgO from the converter lining in the bath that the decision was made to reline the converter and commence a new series of tests on June 25th. (R. 11,943.) In the June 25th series of tests, which involved a reduction in impact pressure of the jet on the bath by means of an increase of nozzle bath distance and the use of a normal nozzle rather than a Laval nozzle, no refractory damage was experienced. (DX 116, 116A.)

The contrast between the June 17th series and the June 25th series of tests at Linz with regard to refractory damage is illustrated by analyses of the magnesium oxide (MgO) content of the slag on the final steel in the converter in these tests. In the June 17th series of tests, the MgO content of the slag varied between 25.87% and 34.3%. In the June 25 tests, on the other hand, the MgO content of the slag varied between 2.08% and 11.16%. Incidentally, no such information is in evidence for the Gerlafingen tests. The significance of the MgO content of the slag lies in the fact that magnesium is not originally contained either in the pig iron or in slag additions to the heat, but comes entirely from the converter lining. The MgO content of the slag, therefore, is a significant measure of refractory wear. (Dr. Trenkler, R. 11,943, 11,943 A.) The substantially lower MgO content of the slag in the June 25th series of tests is objective [82] evidence of a considerable improvement in refractory life over the June 17th series of tests.

The marked improvement in the quality of the steel produced in regard to phosphorus removal in the June 25th series of tests without even the use of an

afterblow, and also the considerable improvement in refractory life indicate strongly to this Court that the June 25th tests at Linz represented a different and more successful process than had been practiced or disclosed by Dr. Durrer and Dr. Hellbruegge. These tests, involving a relatively low impact pressure of the jet on the bath as opposed to the recommendation of Dr. Durrer and Dr. Hellbruegge, remedied what Dr. Trenkler had stated to be the two major defects of the Gerlafingen process, namely, excessive phosphorus content in the steel produced and insufficient refractory life. (R. 11,929.)

(4) Statements by Dr. Durrer and Dr. Hellbruegge Inconsistent With Inventorship

Contemporary statements by Dr. Durrer establish clearly his own opinion that he had nothing patentable to disclose to the men at Linz with regard to an oxygen steelmaking process. In a speech given by Dr. Durrer on May 20, 1949, at Leoben, Austria (PX 307B), Dr. Durrer discussed in general terms the state of the art with regard to oxygen steelmaking. This speech was given roughly a week after Dr. Trenkler's visit to Gerlafingen, at which time defendant contends the invention of the patentees was entirely disclosed to Dr. Trenkler by Dr. Durrer and Dr. Hellbruegge. In this speech, Dr. Durrer stated:

> "What conclusions may now be drawn for the recovery of iron in Austria? In my opinion your native raw materials are suitable for smelting both in the electric low shaft furnace and in the oxygen low shaft furnace; as for the economic [83] feasibility of the problem, I, as a Swiss, cannot make any judgment, but rather only the suggestion that you investigate both procedures very thoroughly. *The question of converting pig iron into steel by means of high purity oxygen ought also to be studied;* it does not seem to be at all out of the question that this method could be of great interest for your country.
>
> *"All these ideas are still in the developmental stage,* but already they indicate the direction which should be taken. In evaluating and pursuing these ideas—if we wish to do a good deed for the more distant future—we must not let ourselves be guided by monetary considerations." (Emphasis supplied.)

Dr. Durrer affirmed this statement as representing his views at that time. (R. 5098-5098A.) In the speech at Leoben, Dr. Durrer did not announce the discovery of a satisfactory steelmaking process which defendant now attributes to him, although the occasion of the speech gave him an excellent opportunity to do so had he, in fact, made such a discovery.

Dr. Durrer's speech at Leoben was delivered at a conference between representatives of four steel companies including Dr. Durrer's company, von Roll, and VOEST. According to DX 24B, a memorandum prepared by Dr. Suess setting forth conclusions of this conference it was stated:

> "In conferences in Leoben from May 19 to 21, 1949, it was decided to undertake a mutual study of the question of Oxygen Blowing in iron works by the Von Roll'sche Iron Works Gerlafingen, Huetten-

werk Huckingen Ag., Alpine Montangesellschaft Donawitz and VOEST Linz. In a discussion between Prof. Durrer, Dir. Springorum, Dr. Leitner, General-direktor Oberegger, Dr. Matuschka and Suess on May 21, 1949, the following procedure was outlined as follows:

"1) All experience and know-how in this field that is or will be at the disposal of the plants, will be reciprocally put at the disposal of all.

"2) The tests that are to be carried out will be financed by the individual plants that conduct them. If the tests should be on a larger scale or if tests for other plants should be conducted, [84] then a distribution of the costs can be discussed.

"3) There will be another conference for the final setting up of this cooperation, to take place in about 4 to 5 weeks in Linz.

"4) In the near future tests will be begun in Huckingen and in Linz with the blowing of pure oxygen in converters or vessels suitable for this process.

"5) Dr. Durrer will act as secretary for this mutual undertaking."

It is difficult to understand why such an arrangement as that disclosed in the memorandum of the Leoben conference (DX 24B) would have been entered into by Dr. Durrer's company if Dr. Durrer and Dr. Hellbruegge had themselves already achieved satisfactory results with oxygen steelmaking experiments at Gerlafingen. If the Gerlafingen results had actually been satisfactory, it is more likely that Dr. Durrer's company

would have attempted to exploit commercially the new steelmaking process for its own sole benefit rather than enter into a joint experimental program with other steel companies and make available all know-how previously arrived at.

In a letter dated May 28, 1949 (DX 89B (6)), acknowledging receipt of the memorandum (DX 24B) of the Leoben conference, Dr. Durrer replied to Dr. Suess:

> "I was overjoyed by the unanimous agreement to carry out the planned joint work and I hope and trust that it will bring us the desired results. The conditions for our work are very favorable, both with regard to subject matter and with respect to the human factor and we will jointly attack the great problem in a spirit of mutual trust."

Dr. Durrer testified that the "great problem" referred to in his letter was the refining of pig iron by blowing it with oxygen. (R. 5099-5100.) However, if the Gerlafingen tests had [85] been as successful as defendant now contends, oxygen steelmaking would no longer have been such a "great problem" as Dr. Durrer apparently believed on May 28, 1949.

On June 9, 1949, a conference between representatives of the four steel companies was held at Solothurn, Switzerland, to discuss the joint work in oxygen steelmaking earlier agreed upon at the Leoben conference. Dr. Hellbruegge prepared a file memorandum (PX 301B) of the Solothurn conference two days later. In this memorandum, it is stated at p. 4:

> "With respect to possible patent applications, Dr. Durrer is of the opinion that this should be decided

only after something on which patent application can be filed is actually on hand. Furthermore, in the course of the discussion, one arrives at the opinion that it would be better to leave the individual parties free to apply for patents or not."

At trial (R. 5107), when asked the question:

"Q. So that your position as of June 9, 1949, was that nothing on which patent application could be filed was actually at hand; is that correct?"

Dr. Durrer replied:

"A. This is correct. And even today I am still of the conviction that the only basic patent for oxygen top blowing is that of Henry Bessemer.
"Q. Dated as of what date, Doctor?
"A. 1856 or 1855."

This answer indicates clearly that Dr. Durrer did not believe in June of 1949 that he had anything patentable over Schwarz or even Bessemer. (See also R. 5215.)

As previously noted, this memorandum (PX 301B) and Dr. Durrer's testimony at trial also indicate Dr. Durrer's opinion at the time of the Solothurn conference that the Schwarz patent [86] contained Dr. Durrer's ideas and that "a patent which contains my ideas does not impede me from using it." (R. 5101.)

Dr. Durrer also testified at trial that Schwarz' work gave no practical results so far as the refining of pig iron into steel by oxygen is concerned. (R. 5084-85.) It would seem to follow that if Schwarz' work led to no practical results, Dr. Durrer's ideas, allegedly contained

in the Schwarz patent, would also have led to no practical results.

It is important to note that neither Dr. Durrer nor Dr. Hellbruegge apparently sought a patent themselves on the basis of the Gerlafingen tests in the spring of 1949. Dr. Hellbruegge admitted at trial that he never filed a patent application on the work done by him concerning the top blowing of oxygen on pig iron in a converter. (R. 4970.) Records of the United States Patent Office show that Dr. Durrer executed assignments of 29 separate patent applications between May 28, 1947, and April 28, 1948 (PX 317), which indicates that he had an active interest in seeking patents. Yet Dr. Durrer admitted at trial that no patent was granted to him covering the steelmaking process experiments at Gerlafingen (R. 5215), and he also admitted that he did not himself file any patent applications (R. 5202). He further testified that he did not know whether his company had filed any such application (R. 5202-03; 5215.) However, there is no evidence in the record of any such application, either by Dr. Durrer himself or his company.

According to PX 302B, a memorandum by Dr. Suess, one of the patentees, covering a conference with Dr. Durrer and Dr. Hellbruegge on September 9 and 10, 1949, the latter two men were [87] of the opinion at that time that new patents should be applied for by the individual companies, but with benefits and participation to all the partners. The same memorandum shows that Dr. Durrer and Dr. Hellbruegge were familiar with the success of the Linz tests in June, 1949, since they thought that a large steel plant could be built at once at Linz using the same process. Apparently, therefore,

Dr. Durrer and Dr. Hellbruegge were content to allow the patentees to apply for a patent on the process at Linz rather than seek a patent themselves. Dr. Durrer was aware of the Suess patent applications in Austria and Switzerland (PX 316B, PX 312B; R. 5199-5200; and R. 5187); and yet he admitted that he never filed an opposition to Suess' applications anywhere in the world and did not remember any such opposition by his company. (R. 5218.)

In a memorandum (DX 89B (20)) dated December 14, 1949, relating to a discussion between Dr. Durrer and Dr. Suess, Dr. Durrer noted that on the basis of the excellent results of the Linz experiments, Linz had decided to construct an oxygen steel plant. Dr. Durrer further stated:

> "The good results consist in particular in the very low contents of carbon, phorphorous and sulfur, *which contradicts all metallurgical expectations. This work shows a new metallurgy with which we must first of all become acquainted.* Presumably, the extensive removal of these substances is due to the higher temperature, the higher degree of liquidity connected therewith and the higher reaction velocity resulting therefrom." (Emphasis supplied.)

This statement appears to contrast the successful work at Linz with the previous experiments at Gerlafingen. Dr. Durrer in his statement registered surprise at the good results of the Linz work, which clearly suggests that comparable results had [88] not been achieved at Gerlafingen by Dr. Durrer himself.

Also, in a letter (DX 89B (22)) by Dr. Durrer to Dr. Suess dated May 5, 1950, Dr. Durrer states:

> ". . . the very successful tests conducted by you have shown that the process based on your steel pig-iron is ready for production. I had not expected you to be able to solve this problem so quickly, and am therefore all the more delighted, now that I have been able to see the beautiful results with my own eyes. Now that the problem has been solved in principle, it is only a question in the further tests of details, of polishing up the process, so to speak . . .
>
> "To you and your co-workers my most sincere congratulations on this important metallurgical progress."

This letter must be read in light of DX 89B (21), a letter from Dr. Suess to Dr. Durrer requesting some such congratulations in order to assist Dr. Suess in his negotiations with his employer VOEST concerning the oxygen steelmaking process at Linz. Such a solicited response is not as convincing evidence of non-inventorship by Dr. Durrer himself as his memorandum (DX 89B (20)) of December 14, 1949. However, the fact that Dr. Durrer was willing to write such a letter extending his congratulations to Dr. Suess is some additional evidence of an advance in the art made by the patentees at Linz.

(5) CONCLUSION

Defendant has admitted repeatedly that the teachings of Schwarz and Dr. Durrer are essentially the same. (See, for example, p. 43 Reply Brief, R. 11,896.) On final argument, in response to the Court's statement:

> "Well, then, you admit that Schwarz and Miles and Durrer and Hellbruegge all teach the same method."

Counsel for defendant stated:

> [89] "There are minor detail differences, but so far as the basic method is concerned, they are alike as peas in a pod. There is no essential difference between them; and if we were able to urge one as doing something, we would have to admit that the other two did the same thing in broad concept." R. 13,503.)

However, defendant also admitted that Schwarz' teachings did not anticipate the patent in suit. (See, for example, R. 143-44, 13,410.) It follows that Dr. Durrer's teachings, admittedly the same as Schwarz', would also fail to anticipate the patent in suit and that Dr. Durrer could not have identically disclosed the subject matter of the patent in suit to the patentees.

It should be noted that at p. 42 of its Reply Brief, defendant attempted to confuse the issue concerning the Durrer and Hellbruegge disclosures, stating:

> ". . . the process of the patent in suit, when compared with the sum of what was learned from Dr. Durrer and Dr. Hellbruegge, must represent an advance amounting to invention."

In effect, this is a statement that the issue is one of obviousness over the Durrer and Hellbruegge disclosures and, therefore, arises under Section 103 rather than Section 102(f), upon which defendant had earlier relied. (See Main Brief, p. 223.) As already discussed, obviousness over the teachings of Dr. Durrer and Dr. Hellbruegge is not an issue in this case, since the teachings of Dr. Durrer and Dr. Hellbruegge do not constitute prior art within the meaning of the patent statute.

In conclusion, this Court finds that the defendant has failed to carry its heavy burden of proving that the patentees did not themselves invent the subject matter of the patent in suit, but rather learned it from Dr. Durrer and Dr. Hellbruegge. [90] Indeed, the evidence indicates that defendant could not have sustained even a lesser burden of proof. In the opinion of this Court, a preponderance of the evidence establishes that the patentees rather than Dr. Durrer and Dr. Hellbruegge were, in fact, the true inventors of the subject matter of the patent in suit. Such conclusion is not intended in any way to minimize the enormous contributions that Dr. Durrer and Dr. Hellbruegge made to the art of steelmaking with oxygen. The ideas and experiments of Dr. Durrer and Dr. Hellbruegge certainly paved the way for the successful experiments at Linz in June of 1949. Indeed, in any objective sense, it would have to be said that Dr. Durrer and Dr. Hellbruegge contributed as much, if not more, to the discovery of the successful oxygen steelmaking process than the patentees. However, the patentees must be credited with the invention under applicable patent law, because they took the final step of reducing impact pressue so as to avoid refractory damage and to create the early fluid slag neces-

sary for satisfactory phosphorus removal. In all other respects, the Linz process is anticipated by the work at Gerlafingen. Yet this final step of reducing impact pressure was the difference between success and failure. In this Court's opinion, Dr. Durrer and Dr. Hellbruegge themselves might well have taken the final step if they had continued their own experiments. Certainly a great deal of credit is owing to Dr. Durrer and Dr. Hellbruegge as well as to the patentees by the steelmaking industry throughout the world for their great contributions to the art of steelmaking. Nevertheless, as the Supreme Court noted in *Cimiotti Unhairing Co. v. American Fur Refining Co.*, 198 U. S. 399, 409 (1905), the patentee had "taken the step which marks the difference between a successfully [91] operating machine and one which stops short of that point, and that advance entitles him to the protection of a patent."

D. Compliance of the Specification With § 112

Defendant has attacked both the specification and the claims of the patent in suit as being too indefinite to comply with the requirements of 35 U.S.C. §112, which provides in pertinent part:

> "The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention."

Section 112 requires simply a disclosure of the invention which would enable persons skilled in the pertinent art to practice the invention. As the Supreme Court stated in *Mowry v. Whitney*, 14 Wall. 620, 644 (1872):

> "The specification, then, is to be addressed to those skilled in the art, and is to be comprehensible by them. It may be sufficient, though the unskilled may not be able to gather from it how to use the invention. And it is evident that the definiteness of a specification must vary with the nature of its subject. Addressed as it is to those skilled in the art, it may leave something to their skill in applying the invention, but it should not mislead them."

Thus the issue under Section 112 with respect to the specification is whether the specification describes the invention sufficiently to enable steelmakers to make and use the invention. The burden of proof on this issue, as with all issues concerning validity, is upon defendant. 35 U.S.C. § 282.

[92] Defendant has made a number of objections to language as well as particular teachings or the lack of such teachings in the specification. Such objections are of no consequence if, despite their accuracy, persons skilled in the art of steelmaking reading the patent could, nevertheless, make and use the invention disclosed by the specification "without the necessity of further experiment itself of an inventive nature." *National Battery Co. v. Richardson Co.*, 63 F. 2d 289, 293 (CCA 6, 1933); *Sun Ray Gas Corporation v. Bellows-Claude Neon Co.*, 49 F. 2d 886, 887 (CCA 6, 1931.)

As the Sixth Circuit Court of Appeals stated in *Paul E. Hawkinson Co. v. Wilcoxen*, 149 F. 2d 471, 475 CA 6, 1945), cited by both parties:

"In determining the sufficiency of these patents the real test is, whether the disclosures in the specifications and claims make the inventions clear to a mechanic skilled in the art of tire retreading so that he could construct the apparatus and practice the method."

In this connection, Dr. Flinn, Professor of Metallurgical Engineering at the University of Michigan, who testified for defendant, admitted that a person skilled in the art could follow the teachings of the examples set forth in the specification and manufacture satisfactory steel. (R. 7885 and 7924.) The examples of the specification were limited to heats of 35 to 36 tons. Dr. Flinn was questioned as follows:

"Q. And the specific conditions there are given for 36-ton heats; right?

"A. Yes.

"Q. And if you follow those specific teachings, you get good steel; right?

"A. Yes." (R. 7924.)

[93] Dr. Flinn also testified that a steelmaker would have difficulty in making good steel following the teachings of the patent with respect to heats of sizes larger or smaller than the 36-ton example. Specifically, he testified:

"A. I think I would have to do a fair amount of experimenting, . . ." (R. 7938.)

The specification teaches a broad range of operating conditions which would cover larger or smaller heats. However, the patent does not give precise numerical teachings such as oxygen blowing pressure or nozzle bath distance to be used for heats of particular sizes

other than 36 tons. The patent states at col. 9, lines 13-17:

"In general, it may be stated that as the oxygen pressure and nozzle diameter are increased, the nozzle spacing is also increased, for example, as the capacity of the refining vessel and total charge is increased."

According to Dr. Flinn, such teaching would not provide sufficient guidelines to persons skilled in the art desiring to manufacture steel in heat sizes of other than 36 tons. In any event, there seems to be no question that the 36-ton heat example of the specification has "set forth the best mode contemplated by the inventor of carrying out his invention," as required by Section 112.

Section 112 does not expressly require a disclosure of the invention so full and comprehensive that a person skilled in the art would not have to engage in any experimentation whatever to make and use the invention for his own particular purposes. Further experimentation of the sort in which Dr. Flinn felt the need to engage in order to make more than 36 tons of steel at a time is not condemned by Section 112, provided that such experimentation is not itself of an inventive nature. *National Battery* [94] *Co. v. Richardson Co., supra,* 63 F. 2d 289, 293 (CCA 6, 1933.)

As the Sixth Circuit Court of Appeals recently stated in *Tilotson Manufacturing Co. v. Textron, Inc., Homelite,* 336 F. 2d 833, 841 (CA 6, 1964):

"A specific example of the carburetor was given in the specification. The fact that some testing may be required in calibrating carburetors for different

engines does not render the claims indefinite where adequate guideposts were furnished as here."

The real question, therefore, is whether the experimentation required to make satisfactory steel in heat sizes larger or smaller than the 36-ton example of the specification would be experimentation "of an inventive nature." In view of the teaching in the specification of a broad range of operating conditions for heats of various sizes and the instruction of col. 9, lines 13-17, that oxygen pressure and nozzle diameter are to be increased along with nozzle bath distance as the size of the heat is increased, and also in light of the general teaching at col. 3, lines 70-75, to avoid deep penetration so as to obtain a fluid slag and to avoid slopping, this Court concludes that the experimentation required to go to a different heat size would not be of an inventive nature. The specification teaches "necessary and required process conditions, such as fluid slag . . . and avoidance of slopping" (col. 3, lines 70-73), indicating the avoidance of a deep penetration. The specification also gives a broad range of operating conditions and an instruction as to their interrelation which would inform the steelmaker in general of the method of obtaining good steel in various heat sizes.

Significantly, McLouth's OP-2 shop, constructed in [95] 1958 and 1960, contains vessels with a capacity of 110 tons (R. 10,957), a considerably larger capacity than that of the OP-1 shop. Mr. Johnson, McLouth's Vice President in charge of engineering, and responsible for the design and construction of McLouth's OP-1 and OP-2 shops (R. 10,950-51), was not examined at trial by defendant concerning the alleged indefiniteness of the

specification, although he would have been the most qualified of defendant's witnesses to testify on this issue. However, plaintiffs put in evidence certain pertinent testimony from Mr. Johnson's deposition taken prior to trial. He apparently encountered no difficulty in going from the heat used in the OP-1 shop to the larger heat used in the OP-2 operation. Specifically, he testified at R. 3494-3497:

"Q. Now, just how did you determine the oxygen flow rates to be used on the 80 and 100 ton vessels in the No. 2 Shop?

"A. We believed from our experience on our No. 1 vessel that we had established certain maximum conditions. If you will remember from the interrogatories, it is necessary in the first few heats of the lining, for example, in Vessel No. 1 to charge for a 52-ton tap instead of a 60-ton. So that we believe that these vessels at our OP-1 Shop are operating at a limiting condition and that this was, I believed, good information, because many of us discussed this problem of limiting size, and to me, of course, the designer, the limit size is a very important number. I thought that we had established these conditions there so it was a simple extrapolation from these maximum conditions that we had determined from our operations.

"Q. What were these maximum conditions that you speak of? What did they relate to?

"A. Principally to depth of bath.

"Q. Flow rates also?

[96] "A. On flow rates also, in the respect that if depth of bath is established, then we would have an extrapolation of oxygen volume also.

"Q. Just how did you make that extrapolation in regard to the oxygen flow?

"A. In comparing tons of metal blown in the two vessels. The actual history is straight extrapolation gas from medium range 3400 to 5700, and considering an 80-ton heat size; and sometime after the units were built, because our operation was in the high part of the range, it was necessary for us to rebuild the oxygen controlling devices, so that the instruments would be more comfortably in the center of the range.

• • •

"Q. And what was the actual designed flow rate that you got by this extrapolation for the 100-ton vessel?

"A. On the 100 ton?

"Q. Yes.

"*Mr. Groner*: You mean by that the A. vessel?

"*Mr. Webb*: Yes.

"A. We in effect did not actually design that, Mr. Webb. The equipment, except for the vessel height, and the fact that we knew the flow meter range was not high enough, the equipment was purchased as being identical equipment, and the instruments for that vessel were bought to handle a higher-range, but we actually did not establish any number. We did not perform tests of lances or establish numbers for A Vessel. It was a simple addition of similar equipment with some improvement."

Mr. Johnson's testimony quoted above concerned primarily the specific features of oxygen flow rate and bath depth. However, there is no reason to assume that he would have given a different answer with respect to other operating factors, keeping in mind defendant's burden of proof on this issue and its failure to call Mr. Johnson as its own witness on this issue. In short, [97] according to defendant's own testimony, persons skilled in the art can make satisfactory steel following the teachings of the 36-ton heat example given in the specification, and a person skilled in the art can apparently extrapolate from such conditions to determine the operating conditions for larger heat sizes.

Additionally, Dr. Elliott demonstrated the manner in which a person skilled in the art of steelmaking in 1950, reading the patent, would be able to design operating conditions for a 100-ton heat. (PX 347; R. 6174-6245.) Such evidence was not refuted by defendant.

The above testimony is sufficient to resolve the issue of indefiniteness of the specification under Section 112. Therefore, this Court need not discuss in great detail defendant's various objections to the specification.

Defendant objects to the language referring to avoidance of deep penetration as a fiction and also a meaningless term. However, it has already been observed that the specification gives the phrase "avoidance of deep penetration" a special meaning by association with "necessary and required process conditions, such as fluid slag, avoidance of over-oxidation (undue loss of iron to the slag), and avoidance of slopping." (Col. 3, lines 70 to 73.) The patent further states: "The process conducted under these conditions

avoids a deep penetration of the oxygen gas into the molten bath which seriously impairs refractory life at the bottom of the refining vessel." (Col. 3, line 73, to col. 4, line 1.) Thus, according to the teaching of the specification, a steelmaker knows he is avoiding deep penetration within the meaning of the patent if he does not blow deeply enough to [98] cause refractory damage or to prevent the formation of a fluid slag, as Dr. Elliott and Dr. Hauttmann testified. (R. 6168-70; R. 2764.) Given this special meaning by the specification, the phrase "avoidance of deep penetration" is certainly not a fiction, since such process conditions as a fluid slag, the avoidance of slopping and the avoidance of refractory damage are admittedly part of the practice of steelmaking at McLouth. (R. 3483-85; 6692-93; 10,-986-92; 11,190-91.)

Defendant also complains that the expressions in the patent relating to "surface blowing" are fatally indefinite. Defendant contends that surface blowing means absence of any penetration whatever by the jet. Such a construction of the term "surface blowing" is inconsistent with the teachings of the patent to avoid deep penetration, which admittedly implies some penetration by the jet (R. 854), at least sufficient penetration to avoid slopping as specifically taught at col. 3, lines 70 to 75. Moreover, as Dr. Hauttmann testified:

> "The words 'surface blowing' only says [sic] that the jet is directed toward the surface, in contrast to what happens if a nozzle or an oxygen jet is blown from below directly into a melt." (R. 2494; see also Dr. Chipman, R. 959-60.)

Defendant's witness Dr. Flinn also recognized this distinction. (R. 8043.)

Defendant objects to the language in the specification referring to the "confined" or "localized" reaction zone as fatally indefinite. It is true that the specification gives the term no precise meaning or definition, at least in terms of numerical percentage of bath area or depth. However, the specification does make clear that the reaction zone must not be [99] of sufficiently large size to cause excessive refractory damage either to the bottom or walls of the vessel. (See, e.g., col. 3, line 73, to col. 4, line 6.) Although the term lacks precision, its indefiniteness would not prevent a steelmaker from making and using the invention on the basis of the disclosures of the specification. As Dr. Chipman testified, a localized reaction zone is characteristic of the process, and cannot be avoided in any event. (R. 907.)

Defendant objects to the alleged inadequacy of the teaching of the specification concerning the interrelation of the broad range of operating conditions taught by the patent. As already noted, the patent teaches at col. 9, lines 14 to 17, that "as the oxygen pressure and nozzle diameter are increased, the nozzle spacing is also increased, for example, as the capacity of the refining vessel and total charge is increased." Defendant contends that such teaching is not helpful because it does not teach to what extent the various operating conditions should be increased. The short answer to this contention is that the specification is directed to persons skilled in the art of steelmaking who, according to plaintiffs' witnesses at least, would be able to make the necessary correlation. As already discussed, experi-

mentation itself of an inventive nature would not be required to arrive at the appropriate correlation of operating conditions for heats of various sizes.

With regard to circulation, defendant contends that the patent's teaching of a down in center circulation is a teaching of a circulation that does not exist in fact. However, such a contention raises no problem under Section 112 concerning definiteness of the specification. The specification as a whole [100] might well be sufficiently definite to enable a steelmaker to make and use the invention, although one portion of the specification suggested a nonexistent phenomenon. Thus, the Court need not decide with respect to this issue whether circulation down in the center exists in fact, as suggested by the specification.

Defendant also objects to an allegedly inadequate disclosure in the specification concerning an appropriate nozzle. However, it was apparently the intent of the patentees that either the Laval nozzle or a normal converging nozzle could be used. (R. 11,906.) Defendant's counsel (R. 124) and its witness, Dr. Flinn (R. 8015), admitted that either a Laval or cylindrical nozzle could be used in practicing the patent process. Therefore, the failure of the patent to specify one type or the other as appropriate raises no issue under Section 112.

Defendant contends that the patent teaching with respect to nozzle diameter is erroneous. At col. 3, lines 59-61, the patent teaches a diameter of about one millimeter per ton of charge, which teaching plaintiffs admit would not apply universally to all heat sizes. (E.g., R. 6423-24.) However, plaintiffs' witnesses testified

that persons skilled in the art would not be misled by the patent teaching regarding nozzle diameter and would be able to compute a proper diameter for the desired heat size. (R. 6664-65; 2472-73.) Defendant has not sustained its burden of proving the contrary. Errors in a patent specification do not render a patent fatally indefinite under Section 112 if such errors do not mislead persons skilled in the art. *International Nickel Company v. Ford Motor Company,* 166 F. Supp. 551, 557 (S.D. N.Y., 1958).

Further, defendant objects to the many references in [101] the specification concerning "high temperatures" in the localized reaction zone as being too indefinite for failure to specify such temperatures in degrees. Again, such objection raises no issue under Section 112, although the term "high temperature" is indefinite, since the indefiniteness of the term in no way would impair the ability of a person skilled in the art to make and use the invention on the basis of the disclosure in the specification.

As the Supreme Court stated in *Eibel Process Company v. Minnesota & Ontario Paper Company,* 261 U. S. 45, 66 (1923):

> "Expressions quite as indefinite as 'high' and 'substantial' in describing an invention or discovery in patent specifications and claims have been recognized by this Court as sufficient."

Dr. Chipman testified that blowing vertically into a bath, a steelmaker cannot avoid the high temperatures referred to in the specification. (R. 1017.)

Finally, defendant refers to several admitted errors in the teachings of the specification. However, defendant has not sustained its burden of proving that such minor errors would mislead persons skilled in the art to such an extent that they would not be able to make and use the invention disclosed by the specification.

In sum, this Court finds that the specification of the patent in suit, despite certain indefiniteness and inaccuracies, nevertheless complies with Section 112 by disclosing the invention in sufficiently clear terms to enable steelmakers "to make and use the same." At least defendant has not sustained its burden of proving otherwise, especially in light of defendant's own testimony that persons skilled in the art could make satisfactory steel following the teachings of the example and that [102] extrapolation to other heat sizes was a simple matter. Defendant's failure to call its own steelmakers as witnesses on this issue weakens its attack on the specification under Section 112.

E. Compliance of the Claims With § 112

35 U.S.C., Section 112, provides in pertinent part:

> "The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention."

Defendant in this case has attacked the claims of the patent in suit as being too indefinite to determine the scope and content of the invention claimed and also as not supported by the specification. There is another objection, not separately argued by the defendant, that the claims do not cover the actual invention by the patentees, as required by Section 112.

(1) THE CLAIMS DO NOT MEASURE THE INVENTION

It has already been noted in connection with the issues of nonobviousness and inventorship that all four of the patentees at one time or another considered a reduced impact pressure of the jet on the bath or the avoidance of a deep penetration of the bath by the jet to be the gist of their invention. (Rinesch affidavit DX 116; Hauttmann affidavit DX 117; R. 2772-73; Trenkler testimony R. 11,904, 11,912 and 11,942; Suess Austrian application PX 2C; U. S. continuation-in-part application PX 2A, claims 1-4; and the German File Wrapper History PX 93B, pp. 31-32 and 41.) For example, Dr. Trenkler defined the invention as follows:

> "A. *In our method we blow only on the surface and a little below.* I do not think I can state that very shortly. It will be about two to three sentences.

"Q. All right.

[103] "A. *Owing to this type of blowing to the upper regions of the bath,* we have an essentially earlier dissolution of the lime, a higher Fe content in the slag, and thereby a faster and better dephosphorization. Owing to the fact that the hot zone caused by the top blowing of oxygen is not deep in the bath, the lining is protected. The third and the last sentence comes now.

"Q. Go ahead.

"A. Owing to the fact that the phosphorus content, that is, the phosphorus burns earlier, that is, prior to the combustion of carbon, we have until the end of the process a carbon monoxide evolution which results in an essentially better movement of the bath than the one that would be caused by the oxygen jet." (R. 11,904. Emphasis supplied.)

The specification of the patent in suit teaches the avoidance of deep penetration as an essential characteristic of the process of the patent. (Col. 3, lines 46, 74; col. 4, line 70, col. 9, line 18.) Further, plaintiffs in this litigation have repeatedly contended that the "new mental concept" that differentiates the invention of the patentees from the prior art Schwarz and Miles patents, and also the teachings of Dr. Durrer and Dr. Hellbruegge, was a reduction in impact pressure so as to avoid the deep penetration suggested by the prior teachings. (See e.g. Plaintiffs' main brief, pp. 37 to 43; reply brief, p. 27; final argument R. 13,184-88; 13,214; 13,269-79.)

At R. 13,187-88, counsel for plaintiffs said:

"They [the patentees] learned that you have to avoid the deep penetration; . . . in other words, they had to reduce the impact pressure.

* * *

". . . They arrived at this thought: 'That maybe we've got to blow this from a higher point. Maybe we've got to cause this oxygen to impinge on the surface of the bath with a lower impact pressure and avoid stirring the bath by the oxygen stream, so what we'll do is to use another nozzle, and we'll also raise the lance further above the bath level.'"

[104] Additionally, at R. 13,769-70, the following colloquy occurred:

"*[Counsel for Plaintiffs]*: The gist of the affidavits, I would say, your Honor, is, if I may summarize it rather quickly, that the primary difference between the L-D process and the process of Schwarz and Miles, which never got anywhere, is that in both Schwarz and Miles they teach deep penetration as a necessity, whereas in the L-D process you avoid deep penetration.

"*The Court*: Isn't that the real gist of the difference between the patent in suit and Schwarz and Miles? Isn't that the real gist?

"*[Counsel for Plaintiffs]*: Yes, your Honor.

"*The Court*: Of the difference?

"*[Counsel for Plaintiffs]*: Yes, your Honor. And that is the thing which is stated here in the affidavits, and the affidavits do not point out that it was a new kind of nozzle, a different kind of

nozzle that is the crux of the invention. The affidavits point out that the crux of the invention was reducing the pressure of the oxygen on the melt so that you did not have this deep penetration.

"*The Court*: That would be the advance in the art, then, over Schwarz and Miles?

"*[Counsel for Plaintiffs]*: I think that is an important feature of it, as I indicated earlier.

"*The Court*: Are there any others?

"*[Counsel for Plaintiffs]*: Beg pardon?

"*The Court*: Are there any others?

"*[Counsel for Plaintiffs]*: Well, I think, as I pointed out the other day in our main brief, we pointed out a number of other distinctions between Schwarz and Miles—

"*The Court*: But that is the main difference?

"*[Counsel for Plaintiffs]*: Yes."

Also, plaintiffs' proposed finding of fact No. 31 speaks of the "new concept of non-deep penetration." There is no question on the state of this record that plaintiffs have repeatedly **[105]** stated the avoidance of deep penetration of the bath by the oxygen jet to be the gist of their invention. Indeed, such a position was essential to rebut the defenses of anticipation, obviousness and non-inventorship. Plaintiffs, having taken this position as to the true nature of the invention to rebut such defenses, are now bound by their position, which, as already discussed at length, is well-supported by the evidence in the record.

For a valid patent, Section 112 requires a statement of claim or claims which particularly point out and distinctly claim the subject matter which the applicants regard as their invention. In the instant case, the avoidance of deep penetration is clearly the subject matter which applicants regarded as their invention, and yet the concept of the avoidance of deep penetration simply cannot be read into the claims of the patent in suit. The language of the claims admittedly does not refer expressly to the avoidance of deep penetration of the bath by the jet (R. 13,772), nor can any language of the claims be construed to contain such a meaning.

The claims of the patent in suit speak of "discharging a stream of oxygen vertically downwardly through the slag layer onto and below the surface of the bath at the central portion thereof." Such language is clearly not restricted to a non-deep penetration and could include a penetration far below the surface of the bath.

Plaintiffs rely on language in the claims referring to the avoidance of "material agitation of the bath by the oxygen stream" and "a localized reaction zone spaced a substantial distance from the refractory lining" as incorporating the concept **[106]** of the avoidance of deep penetration. (R. 13,772-73.) However, these references cannot be so construed.

On the state of this record, this Court is obliged to conclude that the avoidance of deep penetration by the jet is not necessarily causally related to the claim of avoiding "material agitation of the bath by the oxygen stream." In other words, it appears to this Court that even deep penetration would avoid material agitation as defined by plaintiffs. The lack of any causal relation

between deep penetration and material agitation by the jet, or at least the lack of any showing of such relation in this record, will be discussed fully in another connection. (See *infra* II. E. (2) (a).) It is sufficient at this point to observe that no such causal relation has been established in this record that would entitle plaintiffs to read the avoidance of deep penetration into the language of the claims referring to the avoidance of material agitation of the bath by the oxygen stream.

As for the "localized reaction zone spaced a substantial distance from the refractory lining," such a reaction zone could also exist even with deep penetration. Indeed, the Schwarz and Miles patents which taught deep penetration also referred at least indirectly to the existence of such a reaction zone a substantial distance from the refractory lining. (DX 61, Schwarz, pp. 4-5; Miles, pp. 3, 15, 16.) Deep penetration of the bath by the oxygen jet as taught by Schwarz and Miles might well extend to a depth of two-thirds of the bath, for example, still leaving a "substantial distance" of one-third of the bath depth between the reaction zone and the refractory lining. The term "substantial distance" is not given any definite meaning by the patent [107] in suit, and the patent certainly does not teach that one-third of the bath depth, for example, would not be a "substantial distance" within the meaning of the claims. Thus plaintiffs cannot read the avoidance of deep penetration into the language of the claims referring to "a localized reaction zone spaced a substantial distance from the refractory lining."

There is a further reason why the actual invention of the patentees cannot be read into the claims of the

patent in suit. Claims 1 through 4 of the continuation-in-part application, which expressly mentioned the avoidance of deep penetration as an essential feature of the claimed invention, were rejected by the Patent Office and later cancelled by the applicants. (PX 2A.) Instead of pressing claims which expressly mentioned the avoidance of deep penetration by resubmitting such claims and eventually even appealing further rejections, if necessary, the applicants abandoned the use of language referring to the avoidance of deep penetration and later chose to submit the language of the claims as finally approved by the Patent Office, resulting in the issuance of the patent in suit. Therefore, the well-established doctrine of file wrapper estoppel prohibits a construction of the claims finally approved by the Patent Office as containing a concept expressed in language previously rejected by the Patent Office and then abandoned by the applicants. As the Supreme Court stated in *Schriber-Schroth Co. v. Cleveland Trust Co.*, 311 U.S. 211, 220-21 (1940):

> "It is a rule of patent construction consistently observed that a claim in a patent as allowed must be read and interpreted with reference to claims that have been cancelled or rejected, and the claims allowed cannot by construction be read to cover what was thus eliminated from the patent. [108] *Shepard v. Carrigan*, 116 U. S. 593; *Sutter v. Robinson*, 119 U. S. 530; *Roemer v. Peddie*, 132 U. S. 313; *Phoenix Caster Co. v. Spiegel*, 133 U. S. 360; *Hubbell v. United States*, 179 U. S. 77; *Weber Electric Co. v. E. H. Freeman Electric Co.*, 256 U. S. 668; *I.T.S. Rubber Co. v. Essex Rubber Co.*, 272 U.S. 429, 443. The patentee may not, by resort to the

doctrine of equivalents, give to an allowed claim a scope which it might have had without the amendments, the cancellation of which amounts to a disclaimer. *Smith v. Magic City Club,* 282 U. S. 784, 790; *Weber Electric Co. v. E. H. Freeman Electric Co., supra,* 677, 678; *I.T.S. Rubber Co. v. Essex Rubber Co., supra,* 444. The injurious consequences to the public and to inventors and patent applicants if patentees were thus permitted to revive cancelled or rejected claims and restore them to their patents are manifest. See *Leggett v. Avery,* 101 U.S. 256, 259.

"True, the rule is most frequently invoked when the original and cancelled claim is broader than that allowed, but the rule and the reason for it are the same if the cancelled or rejected claim be narrower. *Morgan Envelope Co. v. Albany Paper Co.,* 152 U. S. 425, 429; *Wm. B. Scaife & Sons Co. v. Falls City Woolen Mills,* 209 F. 210, 213; see *Computing Scale Co. v. Automatic Scale Co.,* 204 U. S. 609, 620, 621; cf. in case of disclaimer *Altoona Publix Theatres, Inc. v. Tri-Ergon Corp.,* 294 U. S. 477, 492, 493."

It is unfortunate that the applicants adopted a course of conduct in the prosecution of their continuation-in-part application which resulted in the creation of such an estoppel. This Court is convinced on the state of this record that the "new mental concept" of the patentees to avoid a deep penetration of the bath by the jet was a patentable advance in the art of steelmaking, which explains the adoption of the Linz oxygen steelmaking process by steelmakers throughout the

world. Thus, if the applicants had pressed their claim of avoidance of deep penetration in the Patent Office, so as to particularly point out and distinctly claim the subject matter which the applicants actually regarded as their invention, a valid patent might well [109] have issued. In actual fact, however, the subject matter which the applicants regarded as their invention cannot be read into the language of the claims of the patent in suit and, therefore, the claims do not comply with the requirements of Section 112 for failure to particularly point out and distinctly claim the actual invention of the patentees. "The omission of an indispensable step of a process renders a claim invalid." *Technograph Printed Circuits, Ltd., v. Bendix Aviation Corp.,* 218 F. Supp. 1, 44 (D. Md. 1963), affirmed 327 F. 2d 497 (CA 4, 1964), cert. den. 379 U. S. 826 (1964); citing *Aluminate Co. v. Akme Flue, Inc.,* 50 F. 2d 921 (D. Md. 1931); *Daniel Green Felt Shoe Co. v. Dolgeville Felt Shoe Co.,* 210 F. 164 (CCA 2, 1913); *Pennsylvania Crusher Co. v. Bethlehem Steel Co.,* 193 F. 2d 445 (CA 3, 1951); *Western States Machine Co. v. S. S. Hepworth Co.,* 147 F. 2d 345 (CA 2, 1945), cert. den. 325 U. S. 873 (1945). See also *Ideal Roller & Mfg. Co. v. Sutherland Paper Co.,* 96 F. 2d 675, 677 (CCA 6, 1938). Since the avoidance of deep penetration is clearly an indispensable step and indeed the very gist of the invention, its omission from the claims of the patent in suit renders the claims invalid and the patent in suit must, therefore, be held invalid for this reason alone.

(2) THE CLAIMS ARE NOT SUPPORTED BY THE SPECIFICATION

The claims of the patent in suit are a classic example of what Mr. Justice Fortas in the recent case of *Brenner v. Manson,* 383 U. S. 519, 534 (1966), described as "the highly developed art of drafting patent claims so that they disclose as little useful information as possible — while broadening the scope of the claim as widely as possible." But it is a well-established [110] principle of patent law that the claims of a valid patent must be supported by the specification. As the Supreme Court said in *Schriber-Schroth Co. v. Cleveland Trust Co.,* 305 U. S. 47, 57 (1938):

> "The object of the statute is to require the patentee to describe his invention so that others may construct and use it after the expiration of the patent and to 'inform the public during the life of the patent of the limits of the monopoly asserted, so that it may be known which features may be safely used or manufactured without a license and which may not.' *Permutit Co. v. Graver Corporation,* 284 U. S. 52, 60. It follows that the patent monopoly does not extend beyond the invention described and explained as the statute requires, *Permutit Co. v. Graver Corporation, supra, at* 57; that it cannot be enlarged by claims in the patent not supported by the description, *Snow v. Lake Shore & M. S. Ry. Co.,* 121 U. S. 617; cf. *Smith v. Snow,* 294 U. S. 1; and that the application for a patent cannot be broadened by amendment so as to embrace an invention not described in the application as filed, at least when adverse rights of the public have intervened. *Railway Co. v. Sayles,* 97 U. S. 554, 563, 564; *Powers-Kennedy Corp. v. Concrete Co.,* 282 U. S. 175, 185-186; cf. *Webster Electric Co. v. Splitdorf Electrical Co.,* 264 U. S. 463; *Permutit Co. v. Graver Corporation, supra; Crown Cork & Seal Co. v. Gutmann Co.,* 304 U. S. 159."

In the instant case, several steps of the claims of the patent in suit are not supported by the specification, as required.

(a) *The avoidance of "material agitation of the bath by the oxygen stream"*

The term "material agitation" or "avoidance of material agitation" is admittedly not used or defined in the specification of the patent in suit. (R. 13,326, 13,-327, 13,328; also plaintiffs' main brief, p. 190; Dr. Chipman, R. 879; Dr. Elliott, R. 6627; Dr. Hauttmann, R. 2412.) For example, when Dr. Chipman was asked: "Do you find any teaching anywhere in the patent of [111] the avoidance of material agitation by the oxygen stream during the blow?", he finally answered: "I must reply that I do not know, but that I have been unable in the time I have spent here to locate it." (R. 877-78.)

Also, at R. 880, the following exchange occurred:

> "Q. . . . do you find any teaching in the patent of what is material agitation, or material agitation produced by the oxygen stream, physically?
> "A. I see no definition of it.
> "Q. You don't know from anything in the patent when a harmless agitation becomes a material agitation, do you, Doctor?
> "A. I don't think so."

After Dr. Chipman testified that the patentees advised against material agitation by the jet, he was asked the location of such teaching and replied:

"A. It is illustrated in the claims. Whether it is elsewhere, I don't know.

"Q. That's pretty important, Doctor. Do you want to look a little further?

"A. No. It is either there or it isn't.

"Q. Well, is it? You have qualified as an expert on this patent. I want your answer.

* * *

"A. The advice is implied rather than explicit.

"Q. You can't find any such advice, can you, Doctor?

"A. No, not explicit." (R. 886-87.)

Plaintiffs attempted to avoid the effect of such omission by citing the case of *A. S. Boyle Co. v. Harris-Thomas Co.*, 18 F. Supp. 177, 181 (D. Mass. 1937) for the proposition that "The patentee is not bound to use in his claims the precise [112] phraseology with which he sets forth the invention in his specification." It is true that the same "precise phraseology" is not required, but there must be at least some antecedent language in the specification to support the claim. No such language can be found in the specification of the patent in suit.

There is only one reference in the specification which appears to this Court to relate to the claim of avoidance of material agitation of the bath by the oxygen stream. As already mentioned, at col. 6, lines 66 to 72, the patent teaches that at the end of the blow, when carbon combustion has been completed, "the bath becomes relatively quiet," and "the turbulence of the

bath and slag due to the oxygen stream impinging from directly above is insufficient to cause continuance of oxygen-metal reactions." Plaintiffs rely on such quieting of the bath at the end of the blow as evidence of the avoidance of material agitation of the bath by the jet. (E.g., main brief, pp. 262-68.) Such reference in the specification to the quieting of the bath would give only a very restricted meaning to the concept of avoidance of material agitation. Under the teaching of such reference, the material agitation of the bath to be avoided would be that amount of agitation by the jet which would suffice to prevent quieting of the bath or to cause continuance of oxygen-metal reactions at the end of the blow when carbon combustion has been completed. The Court can attribute no more meaning than this to the language of the claims concerning the avoidance of material agitation, at least on the basis of the teaching of the specification. And since, as a matter of fact, it has not been established that there could ever actually be an agitation by the jet that would prevent such quieting of the bath at the end of the [113] blow, the avoidance of material agitation so defined would appear to be inevitable.

In support of the claim of avoidance of material agitation, plaintiffs also rely upon the teaching of the specification in col. 3, lines 37 to 40, that the jet is blown vertically downward upon the central portion of the bath. According to the undisputed testimony of Dr. Elliott (R. 6162) and also Dr. Chipman (R. 1066), such positioning of the lance results in the least possible amount of agitation of the bath by the oxygen stream. In other words, any other placement of the lance, either

at an angle or off center, would increase the agitation of the bath by the mechanical action of the oxygen stream. Such teaching of vertical blowing does not provide adequate support for the claim of avoidance of material agitation by the jet, since the teaching of vertical blowing toward the center of the bath is itself expressly referred to in the claims by the language: "discharging a stream of oxygen vertically downwardly through the slag layer onto and below the surface of the bath at the center portion thereof." Therefore, if the concept of avoidance of material agitation were supported only by the teaching of vertical blowing at the bath center, the language of the claims concerning avoidance of material agitation would be merely surplusage. Further, it is clear from the claims that the language concerning avoidance of material agitation must be read with reference to penetration by the jet, rather than placement of the lance, since the claim speaks of blowing "onto and below the surface . . . to an extent to avoid material agitation of the bath by the oxygen stream."

[114] Plaintiffs find primary support for the claim of avoidance of material agitation by the oxygen stream in the teaching of the specification to avoid deep penetration, relying on the testimony of Dr. Elliott, a Professor of Metallurgy at Massachusetts Institute of Technology who testified for plaintiffs, that the avoidance of deep penetration results in the avoidance of material agitation of the bath by the jet (R. 6162-66.) However, plaintiffs have admitted that the specification does not expressly teach any such correlation. In final argument, for example, the following colloquy occurred:

"*[Counsel for Plaintiffs]*: . . . And then we have the teaching in regard to the avoidance of deep penetration.

* * *

"And, of course, where you avoid deep penetration you avoid this material agitation of the bath by the oxygen stream.

"*The Court*: Yes, that is what you say. That is true. But the specification doesn't use that language.

"*[Counsel for Plaintiffs]*: That is correct.

"*The Court*: It doesn't say that if you avoid deep penetration that material agitation would be avoided. It doesn't say that in so many words.

"*[Counsel for Plaintiffs]*: That is correct, your Honor." (R. 13,329.)

According to Dr. Elliott's testimony (R. 6638-42), the specification of the patent in suit teaches a correlation between the avoidance of deep penetration and the avoidance of material agitation at six different places. The Court concludes on examination of the six references cited by Dr. Elliott, and hereinafter referred to, that no such correlation is in fact taught by the specification. At col. 3, lines 37 to 50, the [115] patent teaches only vertical blowing without deep penetration so as to produce "a relatively confined zone of direct oxygen to molten metal contact with respect to the total surface area of the bath." Agitation of the bath by the jet is not mentioned. At col. 4, lines 26 to 38, the patent teaches only that vertical blowing brings about a circulation of the bath down in the center away from the

localized reaction zone. Again, agitation of the bath by the jet is not mentioned. At col. 4, lines 54 to 67, the patent teaches that agitation of the bath caused by chemical reactions in the localized reaction zone augments a pre-existing circulation of the bath brought about by the jet. Agitation of the bath by the jet is again not mentioned or said to be insignificant in comparison with agitation caused by chemical reactions. At col. 6, lines 69 to 73, the patent teaches that once carbon combustion is completed, "The turbulence of the bath and slag due to the oxygen stream impinging from directly above is insufficient to cause continuance of oxygen-metal reactions." This language is the sole reference in the specification of the patent to an agitation of the bath by the jet. In this reference, no mention is made of the depth of penetration. Certainly this reference does not expressly teach that only the avoidance of deep penetration results in the avoidance of material agitation of the bath by the oxygen stream. No causal relation between deep penetration and material agitation is taught. The other two references cited by Dr. Elliott at col. 9, lines 6 to 14, and in col. 10 of the patent specification, merely give some exemplary blowing information for heats making good steel, and the references teach nothing expressly about either penetration or agitation by the jet.

[116] Thus on close examination, none of the references relied on by plaintiffs teach any causal relation between deep penetration and material agitation by the oxygen stream. Plaintiffs merely assume that the two concepts are causally related. However, if such an assumption is not taught by the specification itself, then persons skilled in the art of steelmaking reading the patent are not informed of the meaning of language in the claim referring to the avoidance of material agitation by the oxygen stream.

Further, as already discussed, the doctrine of file wrapper estoppel prevents a reading of the claim of avoidance of material agitation as supported by the specification's teaching of avoidance of deep penetration, since claims previously submitted by the applicants which had expressly referred to the avoidance of deep penetration were rejected by the Patent Office and later cancelled. (PX 2A.)

Significantly, no causal relation between the avoidance of deep penetration and the avoidance of material agitation was expressed anywhere in the file wrapper history of the patent in suit until June 11, 1957, when the affidavits of Dr. Rinesch and Dr. Hauttmann (DX 116, 117) were filed in the Patent Office. On the same date, the language of the claims concerning the avoidance of material agitation by the oxygen stream was presented to the Patent Office for the first time. The affidavits and the new language of the claims were clearly submitted to the Patent Office in response to its rejection of previous claims in light of the Miles patent, which taught that the jet agitated the bath. (DX 61, Miles, p. 18.) The language of the new claims concerning the avoidance of material agitation was, therefore, an obvious attempt [117] to distinguish the Miles patent. In a letter to the Patent Office submitted together with the affidavits and the new claims, counsel for the applicants stated:

> "It will be appreciated that the conditions of the reaction and for practicing the method are very

different, indeed, from anything shown in the prior art and particularly the process disclosed in the Miles et al. French patent." (PX 2A, p. 77.)

At the time the new claims were submitted, no changes were made in the specification.

Plaintiffs contend that the specification must be construed in light of what it would teach persons skilled in the art, and argue further that persons skilled in the art of steelmaking would know what was meant by the language of the claims referring to the avoidance of material agitation by the oxygen stream. In this regard, it is unquestionable that the sufficiency of a specification in a patent application must be tested in light of what it conveys to those who are skilled in the pertinent art at the time the invention was made, *Application of Wilke,* 314 F. 2d 558, 565 (C.C.P.A. 1963).

The evidence established that the concept of avoidance of material agitation of the bath by the jet would not have been meaningful to persons skilled in the art at the time the invention was made. The Schwarz and Miles patents do not mention the concept of "material agitation" and neither patent teaches any causal relation between deep penetration and material agitation. The Miles patent does teach that the jet agitates the bath (DX 61, Miles, p. 18) but does not expressly teach deep penetration. Certainly Miles does not teach that *only* deep penetration would agitate the bath materially. Thus, even if the contenton of the [118] Rinesch and Hauttmann affidavits in 1957 that only deep penetration causes material agitation were accepted by this Court, the patent teaching of the avoidance of deep penetration would still not suffice under Section 112 to support the

claim of avoidance of material agitation, since persons skilled in the art of steelmaking at the time the invention was made reading the patent would not be aware of any such causal relation and would, of course, not be responsible for knowing the contents of affidavits filed more than seven years later.

Further, plaintiffs have defined material agitation by the jet as agitation sufficient to overcome circulation created by chemical reactions. (Main brief, pp. 191-92; R. 13,331-32. See also Dr. Chipman, R. 889-900A, 1064, 1066; Dr. Elliott, R. 6167.) However, there is no evidence that in 1950, a circulation induced by chemical reactions was known to persons skilled in the art, or at least taught by the prior art. Neither the Schwarz nor the Miles patent teaches a circulation or agitation of the bath produced by chemical reactions or the direction of any circulation of the bath. Indeed, the concept of reaction-induced circulation would not necessarily be recognized by persons skilled in the art even today, for it is not clearly taught by the specification of the patent in suit and there was disagreement in the expert testimony at trial as to its existence. In any event, if reaction-induced circulation were not known to persons skilled in the art at least in 1950, the concept of material agitation by the oxygen stream which would overcome such circulation would also have been unknown to such persons.

In addition, persons skilled in the art who testified for plaintiffs did not seem to know what the language of the [119] claims referring to material agitation meant or to be able to tell when the conditions of such agitation or its avoidance would exist. For example, when Dr.

Hauttmann, one of the patentees, was asked: "How would an operator practicing oxygen blowing tell when the agitation produced by the jet became material?", he answered: "I do not know that." (R. 2414.) When Mr. Prince, a metallurgical engineer employed by plaintiff Kaiser, was asked: "When does agitation become material?", he finally replied: "I don't know, Mr. Groner. It is just when agitation becomes material." (R. 5784.) Also, when Dr. Chipman was asked: "You don't know from anything in the patent when a harmless agitation becomes a material agitation, do you, Doctor?", he replied: "I don't think so." (R. 880.)

Thus this Court concludes that the claim step of avoidance of material agitation of the bath by the oxygen stream is not supported by the specification of the patent in suit except in a very limited and perhaps meaningless way, and could not have been a meaningful concept to persons skilled in the art at the time the invention was made, especially since the concept did not appear very meaningful to some of plaintiffs' expert witnesses even at the trial roughly fourteen years later.

This Court is further persuaded on the basis of plaintiffs' own testimony that the concept of material agitation of the bath by the oxygen stream is purely fictional, since plaintiffs' own testimony strongly suggests that materal agitation by the jet could not be achieved even with deep penetration. Dr. Ascher H. Shapiro, a professor of Mechanical Engineering at Massachusetts Institute of Technology, a witness for plaintiffs, [120] testified that the force of chemical reactions which would tend to create a downward circulation in the center of the bath would be roughly 3,000 times

stronger than the force of the jet blowing vertically from above (R. 3772-73; PX 267), and that the "power" of such reactions would be more than 8,000 times stronger than that of the jet. (R. 3801; PX 272.) In view of the tremendous force of chemical reactions agitating the bath and initiating a circulation downward in the center of the bath as compared with the relatively feeble agitating power of the jet, it seems impossible that a deep penetration by the jet could overcome or even materially affect such circulation, so as to cause a material agitation by the oxygen stream.

Dr. Shapiro's testimony was confirmed, in effect, by Dr. Elliott (R. 6280), and also Dr. Chipman, who apparently concluded that there could be no such thing as material agitation of the bath by the oxygen stream when making steel by an oxygen top blowing process. Specifically Dr. Chipman testified:

> "The teaching that I find in the patent wth respect to agitation leads me to conclude and understand that the agitation which is present in actuality is far greater than the agitation by the oxygen stream, compared to which the agitaton of the oxygen stream becomes immaterial." (R. 880.)

Also, when he was asked:

> "If a manufacturer, a steel maker, came to you as an expert and asked you how much agitation he would have produced by the oxygen stream and still stay outside the patent, what would you advise him?"

Dr. Chipman replied:

> ". . . I would say, however, that he would not be able to get oxidation by the oxygen stream—agita-

tion by the oxygen stream. He would not get agitation by the oxygen stream of the molten metal. . . . He would never see the agitation that he [121] gets. He would never know that the oxygen stream was doing any agitating, because there are so much more active forces— . . . agitating . . ." (interrupted). (R. 880-81.)

Dr. Chipman defined material agitation negatively as follows:

"If there are other sources of agitation which overshadow the agitation of the simple action of the gas on the metal, then I think you do not have material agitation." (R. 889.)

He continued to speak of agitation by the oxygen stream, stating:

"You know that by comparison with other phenomena, it is very small." (R. 900. See also R. 879, 886-87, 1065-66.)

Significantly, plaintiffs admit that there is no evidence in the record that deep penetration would, in fact, cause material agitation. On final arguments, the following discussion occurred:

"*The Court*: Then if there is in fact the deep penetration, like under Schwarz and Miles, or, as you claim, under Durrer and Hellbruegge—if there is in fact deep penetration, does the agitation of the bath caused by deep penetration overcome the circulation caused by the chemical reactions?

"*[Counsel for Plaintiffs]*: I don't know whether that would be the exact case when you are blowing under those circumstances—that is, blowing very deeply into the bath. I don't know whether the mechanical action would be supreme or what the effect would be. I don't believe it's covered by the evidence." (R. 13,332-33.)

Likewise, Dr. Chipman testified that he did not know whether, in fact, deep penetraton would cause agitation of the bath. (R. 949-51.) And Dr. Hauttmann testified that he had had no experience regarding deep blowing from above. (R. 2519.)

There is, moreover, tangible evidence in the record tending to confirm that the concept of material agitation by the oxygen stream is a fiction. During the trial of this litigation, defendant's witnesses conducted an oxygen steelmaking demonstration (No. 7) in the presence of this Court in the Cast Metal [122] Laboratories of the University of Michigan at Ann Arbor. Demonstration No. 7 involved a deep penetration of the metal bath by the oxygen jet, as established by damage to the refractory bottom visible after the heat was concluded and the converter was emptied of molten metal. Portions of the demonstration were recorded in a movie (DX 162D) viewed by the Court both during and after the trial. During the major part of the blow as shown in the movie, large amounts of slag and metal were thrown up and out of the converter onto the floor, indicating a violent agitation of the metal bath. However, during the last few seconds of the blow when the chemical reactions in the bath had subsided, there was no throw-out whatever, although the blowing pressure of the oxygen jet, according to a gauge visible in the movie, remained at forty pounds per square inch, at which pressure considerable throw-out of metal and slag had previously occurred. In other words, the agitation of the bath as shown by the throw-out subsided near the

end of the blow, although the action of the oxygen jet remained constant. If the bath agitation causing such throw-out of metal and slag had been caused by the mechanical action of the oxygen stream alone, the throw-out would not have ceased as it did near the end of the blow. It is obvious, therefore, that the action of the oxygen stream alone was not responsible for the agitation of the bath causing throw-out of metal and slag during the major part of the blow. Plaintiffs rely heavily on such quieting of the bath at the end of the blow in defendant McLouth's steelmaking operations as evidence that McLouth avoids "material agitation of the bath by the oxygen stream". Applying plaintiffs' own argument, "material agitation of the bath by the oxygen stream" was also avoided in demonstration No. 7 despite deep [123] penetration of the bath by the oxygen jet. But if material agitation by the oxygen stream is avoided even with deep penetration, then the concept of material agitation by the oxygen stream is clearly a fiction, since such agitation is apparently always avoided when blowing vertically, regardless of the depth of penetration.[8] Demonstration No. 7 illustrates that

8. It should be noted that in another of defendant's demonstrations to the Court in Ann Arbor, Michigan, No. 5, no refractory damage occurred and good steel was made without an afterblow, which suggested an avoidance of deep penetration within the meaning of the specification of the patent in suit. In demonstration No. 5, as well as in demonstration No. 7, the bath quieted down at the end of the blow, as shown by the disappearance of throw-out in the movie (DX 160D) recording portions of the demonstration. Thus, applying plaintiffs' argument, material agitation of the bath by the oxygen stream was avoided in demonstrations involving both deep and non-deep penetration of the bath by the jet.

even with deep penetration of the bath by the jet, such agitation of the bath as may occur results from chemical reactions rather than the mechanical action of the oxygen jet upon the bath. But if deep penetration as well as non-deep penetration fails to bring about an agitation of the bath by the oxygen stream, as in demonstration No. 7, then there can be no logical correlation between the avoidance of deep penetration and the avoidance of material agitation of the bath by the oxygen stream. It follows that the teaching of the specification to avoid deep penetration does not provide support for the language in the claims of the patent in suit "to avoid material agitation of the bath by the oxygen stream."

Dr. Elliott was the witness at trial upon whom plaintiffs primarily relied to establish support for the claim step of avoidance of material agitation by the jet. He defined the avoidance of material agitation by reference to the formation [124] of an early fluid slag during the blow, production of steel low in phosphorus, and the avoidance of refractory damage. (R. 6167.) Dr. Elliott similarly defined avoidance of deep penetration with reference to the same three factors. (R. 6169.) Thus his definitions apparently represent an attempt to equate material agitation with deep penetration. However, as already noted, the specification of the patent in suit does not teach any such correlation between the two concepts, and in fact the doctrine of file wrapper estoppel prohibits any such construction of the claim, since claims previously submitted expressly referring to the avoidance of deep penetration were rejected and then cancelled by the applicants. (PX 2A.) Moreover, demonstration No. 7, along with other evidence already dis-

cussed, established a lack of any correlation between the two concepts in fact, since such evidence indicates that material agitation by the jet will be avoided even with deep penetration by the jet. Dr. Elliott himself relied on the quieting of the bath at the end of the blow as in demonstration No. 7 as a sign of avoidance of material agitation of the bath by the oxygen stream. (R. 6278-79.)

Even assuming that the Court could accept Dr. Elliott's equation of material agitation with deep penetration, the meaning of material agitation would still not be adequately clarified, since even the concept of deep penetration does not acquire a clear or consistent meaning from Dr. Elliott's testimony. For example, he testified that deep penetration causes an up in the center circulation, which may cause refractory wear on the walls near the bath surface. (R. 6146-56; PX 349.) However, he later testified that deep penetration causes bottom damage to the refractory (R. 6166) as the result of a downward moving stream of [125] hot metal in the center of the bath. (R. 12,340-43, 12,363.) Clearly, circulation cannot be both up and down in the center at the same time.

In addition, Dr. Elliott gave inconsistent definitions of deep penetration, as illustrated by defendant's demonstration No. 9 to the Court in May, 1964, at Ann Arbor Michigan. In demonstration No. 9, a hole was burned through the bottom of the refractory, permitting the molten metal in the converter to run out into a pan beneath the converter. (See movie, DX 164D.) Dr. Elliott defined deep penetration by reference to such bottom damage (R. 6168-69), testifying also that "deep penetration arises when the jet enters more than, say, 35 to 40 per cent of the bath depth." (R. 6637.) From this testimony it seems that Dr. Elliott would have regarded the penetration in demonstration No. 9 as being at least 35 to 40 per cent of the bath depth. Yet he later testified that the penetration of the jet in demonstration No. 9 was no more than 1.5 inches of a 6.8 inch bath depth, or approximately 22 per cent of the bath depth (R. 12,382, 12,610), using Dr. Shapiro's correction factor of 0.233 to arrive at his estimate. (PX 231, 232.) Such contradictions appear to weaken Dr. Elliott's testimony with respect to the meaning of avoidance of material agitation by the oxygen stream.

Finally, the language in the claims concerning the avoidance of material agitation of the bath by the oxygen stream, although relied on by plaintiffs as a characteristic of the claims essential to novelty, appears under plaintiffs' own definition of the phrase to be mere surplusage in the claims. Plaintiffs take the position that material agitation by the jet is avoided unless [126] a down in center circulation induced by chemical reactions is overcome by the force of the jet. (E.g. main brief, pp. 191-94; R. 13,331-32.) But if such material agitation is avoided whenever a reaction-induced circulation is not overcome by the mechanical action of the jet, then the reference in the claims to the existence of a circulation induced by chemical reactions is the only language in the claims necessary to express the idea, and the language referring to the avoidance of material agitation by the jet is merely extraneous.

As previously stated, it appears to this Court that the real reason for the inclusion of language in the

claims of the patent in suit concerning the avoidance of material agitation by the jet was the desire by the applicants to distinguish the prior art Miles patent, which expressly taught that the jet itself agitated the bath. In effect, the specification of the patent in suit presented a new theory of agitation caused by chemical reactions, and the claims referred to an avoidance of agitation by the jet to give the impression of an entirely new steelmaking process. However, if material agitation by the oxygen stream is a fiction, as defendant's demonstration No. 7 and other evidence strongly suggest, then even under the process as taught by Schwarz and Miles, chemical reactions rather than the mechanical action of the jet must have been the actual cause of agitation in the bath. At least plaintiffs have failed to prove otherwise. And if the language of the claims of the patent in suit referring to the avoidance of material agitation covers the actual practice of steelmaking under the Schwarz and Miles patents, then plaintiffs can hardly rely on such language of the claims as a characteristic of the process essential to novelty. In other words, if Schwarz **[127]** and Miles avoided material agitation of the bath by the oxygen stream even with deep blowing, then such avoidance of material agitation by the oxygen stream cannot be considered a significant feature of the claims of the patent in suit.

(b) *Chemical reactions "producing a circulatory movement in the molten metal"*

The claim of a circulatory movement in the molten metal produced by chemical reactions in a localized reaction zone is simply not supported by the teachings of the specification of the patent in suit. References relied on by plaintiffs in this connection do not teach a circulation induced by chemical reactions. Col. 4, lines 26-38, teach, on the contrary, that

> "application of the oxygen jet substantially vertically or approximately vertically upon the central portion of the bath surface brings about a flow in the molten metal from the center of the surface of the bath downwardly and then along the bottom of the refining vessel, and upwardly at the sides of the vessel to the surface of the bath, so that portions of the unrefined metal are continuously presented to a localized center of direct oxygen reaction with the bath metal, while reacted or oxidized portions of the bath move away from this reaction center."

This language clearly refers to a circulation brought about by the application of the jet upon the bath surface. Chemical reactions are not mentioned in this reference as a factor in creating circulation, as Dr. Hauttmann, one of the patentees, admitted (R. 2515.)

Col. 4, lines 43-67, also relied on by plaintiffs, teach that

> "initial contact of the high purity oxygen jet with the molten metal bath causes a rapid combination of oxygen and iron to form FeO in the confined central reaction zone . . . [and that] A portion of

> the iron oxide goes to the slag with the other oxidized elements and a portion diffuses into the bath under the influence of the [128] bath circulation, so that within the first three minutes of the blowing vigorous carbon combustion is initiated due to the high temperatures developed by these reactions. The ensuing reaction of carbon with the FeO and directly with the oxygen gas in the confined direct oxidation zone causes rapid formation of carbon monoxide *and the formation of this CO causes a strong boil or agitation of the bath, which augments the bath circulation to continuously present unrefined metal to the oxygen gas reaction zone* and to create a slag-metal emulsion." [Emphasis supplied.]

This reference teaches that carbon monoxide formation causes a strong boil or agitation of the bath within the first three minutes of the blow, which "augments" the bath circulation already in existence brought about by the application of the oxygen jet as taught in col. 4, lines 28-34. The reference teaches that chemical reactions produce only an "agitation of the bath" rather than circulation, and that the agitation thus produced merely "augments" circulation already in existence.

Col. 6, lines 62-72, also relied on by plaintiffs, state:

> "The vigorous boil, above mentioned, continues up to the carbon end point, and together with the induced circulation of the bath metal toward and away from the central zone of direct oxygen reaction, effectively counteracts any tendency to over-oxidation of the bath. When the flame dies and carbon combustion is completed, the bath becomes relatively quiet and intimate contact between slag and metal bath ceases. The turbulence of the bath and slag due to the oxygen stream impinging from directly above is insufficient to cause continuance of oxygen-metal reactions."

This reference does *not* teach that when chemical reactions cease, circulation of the bath also ceases. Thus no casual connection is made explicit in this reference between chemical reactions and circulation. The reference does refer to "the induced circulation of the bath metal toward and away from the central zone of direct oxygen reaction." However, this language clearly refers back to the teaching of col. 4, lines [129] 28-34, of a circulation induced by the application of the jet to the bath surface. Such language cannot be read as teaching a circulation "induced" by chemical reactions, in light of the clear teaching of col. 4, lines 63-67, that chemical reactions cause only "a strong boil or agitation of the bath." The sentence at col. 6, lines 62-66, that mentions the "induced circulation" also refers to a "vigorous boil, above mentioned," which clearly refers back to the teaching of col. 4, lines 63-67, of a boil caused by chemical reactions that merely augments the pre-existing circulation brought about by the mechanical action of the jet.

Thus, none of the references in the specification relied on by plaintiffs teaches in so many words that circulation of the bath is produced by chemical reactions as claimed. The specification teaches a circulation brought about by the jet and merely augmented by a strong boil or agitation of the bath resulting from subsequent chemical reactions.

Plaintiffs also rely on a reference in the specification of the original patent application of Dr. Suess (PX 2B) to support the claim of reaction-induced circulation. This reference states:

> "In carrying out the present process as a refining treatment of iron with oxygen, upon blowing oxygen to the surface of molten iron, gas formation takes place by local reaction between the oxygen and the carbon present in the iron, and this gas formation causes strong movement in the molten bath. The reaction gases exert pressure in downward direction, because their escape in upward direction is checked by the pressure of oxygen and the presence of slag. Thus, a movement of the molten material in the direction of the gas stream results. The stream of molten material turns by 90° when reaching the bottom of the reaction vessel and moves finally in upward direction along the walls of the vessel." (PX 2B, pp. 3-4.)

[130] There is no such teaching in the specification of the continuation-in-part application which finally became the specification of the patent in suit and, therefore, the teaching of the original specification relied upon by plaintiffs must be considered as abandoned in the continuation-in-part application. In any event, there is no need to look beyond the specification of the patent itself because it is not ambiguous on this point. Incidentally, the reference in the original specification recites a theory of circulation inconsistent with the theory of circulation advanced by plaintiffs' expert witnesses at trial and is, therefore, not a teaching upon which plaintiffs would wish to rely very strongly.

Plaintiffs contend that the claim of reaction-induced circulation is supported by the teaching of the specification at col. 4, lines 32-34, of a circulation down in the center, which admittedly could only be caused by chemical reactions. (E.g., defendant's main brief, p. 52.) However, even though there may have been no dispute at trial that a down in the center circulation could only be brought about by chemical reactions, such is not the teaching of the specification. Col. 4, lines 26-38, already quoted, teach that a down in center circulation is brought about by the application of the oxygen jet and no mention is made of chemical reactions as a factor in initiating circulation.

Moreover, the teaching of a down in center circulation does not provide adequate support for the claim of a circulation induced by chemical reactions because the claim is not limited to any particular direction of circulation. Indeed, plaintiffs rely on the fact that the claim mentions no direction of circulation to justify a finding of infringement even if the Court **[131]** should find that the circulation in defendant's operations is a reaction-induced circulation up in the center. For example, at p. 385 of plaintiffs' main brief, it is stated:

> "McLouth does not dispute the fact that it obtains a circulatory movement in the bath in its operations. It does contend that the *direction* of circulation in its operation is the opposite of the direction of circulation taught in the *specification* of the Suess et al. patent (McLouth's Trial Brief, p. 101). However, the patent *claims* do not specify any direction of circulation. They specify merely the cause of the circulatory movement. Thus, even if

> the direction of the circulation is opposite to that set forth in the *specification,* it is of no consequence if the circulation is caused by the chemical reactions as specified in the clams." (Emphasis in original. See also R. 13,287.)

If the specification teaches only a down in center circulation, then the claim, which is not limited to any direction of circulation, would clearly overclaim the specification. As already noted, the Supreme Court in *Schriber-Schroth Co. v. Cleveland Trust Co.,* 305 U. S. 47, 57 (1938) stated:

> ". . . the patent monopoly . . . cannot be enlarged by claims in the patent not supported by the description . . ."

If plaintiffs were to argue in response to such conclusion that the claim is actually limited to a circulation down in the center because a reaction induced circulation can be *only* down in the center, such an assertion is certainly not taught by the specification, nor would it necessarily be known to persons skilled in the art even today. For example, the Cuscoleca patent, No. 2,803,534, which was issued August 20, 1957, teaches a circulation up in the center as a result of chemical reactions. (DX 68.) Certainly an allegation that circulation of a molten metal bath produced by chemical reactions could only be down in the center would not have been a fact known to persons skilled in the art in [132] 1950, since at that time there was no general knowledge among steelmakers of a reaction-induced circulation. An "explosive bubble" mechanism which would tend to justify a conclusion that reaction-induced circulation in a molten metal bath could only be down in the center was

advanced by Dr. Chipman and Dr. Shapiro for the first time at the trial of this litigation in 1963 and 1964 (R. 480-82, 490-92, 496-500, 3693-98), and was admittedly not contained in any literature prior to the time of trial. (R. 4250-51.)

In sum, plaintiffs are forced to engage in tortured construction of the specification and claims in the patent in suit in order to find support in the specification for a claim of reaction-induced circulation. In view of the relative ease with which such a claim could have been supported by even a sentence or two in the specification, this Court is unwilling to overlook plain language of the specification to find support for such claim.

(c) *Blowing "below the surface"*

At least thirteen separate references in the specification of the patent in suit speak of "surface blowing" or "blowing onto the surface," etc. But there is no reference anywhere in the specification to blowing "below the surface," as claimed. Col. 5, lines 61 and 62, speak of "the confined zone of direct oxygen *reaction at the surface* of the molten metal bath," (emphasis is added) which would seem to preclude a claim of blowing below the surface. Plaintiffs find support for the claim of blowing below the surface in the teachings of the specification to avoid deep penetration, and also defendant's admission (R. 854) that from such teachings "there may be implied some penetration." [133] However, the word "below" would seem to cover even a deep penetration of the bath by the oxygen stream, which is certainly not taught by the specification. The ambiguity of the word "below" in the claims would justify the Court in

looking beyond the patent itself to the file wrapper history to help resolve such ambiguity. As the Sixth Circuit Court of Appeals observed in *Bobertz v. General Motors Corporation,* 228 F. 2d 94, 97 (1955), cert. den. 352 U. S. 824 (1956):

> "The claims of a patent are to be interpreted, not only in the light of the specifications, but also with reference to file-wrapper history."

The file wrapper history in this case (PX 2A) indicates that the language "below the surface" was added to the claims for the first time on June 18, 1957, only shortly before the patent was issued, and apparently in response to the rejection of previous claims of blowing "onto the surface" as unpatentable over prior art. Further, counsel for the applicants had previously argued to the Patent Office that the avoidance of deep penetration meant "a practically negligible penetration of the surface of the molten metal by the oxygen jet." (PX 2A, p. 68.) Under such definition, the teaching of avoidance of deep penetration in the specification would support a claim of blowing "below the surface" only to "practically negligible" degree. But even disregarding the file wrapper history, the Court concludes that the teaching in the specification of an avoidance of deep penetration is not adequate support for a broader claim of blowing "below the surface."

[134] (3) THE CLAIMS COVER PRIOR ART

The broad scope of the claims, as compared with the specification of the patent in suit, is demonstrated by the fact that according to plaintiffs' own testimony, the inference can fairly be drawn that even a person

practicing the prior art would infringe the process of the claims.

Blowing "onto and below the surface" is certainly taught by the Schwarz and Miles patents.

As for the avoidance of "material agitation of the bath by the oxygen stream," according to the testimony of Dr. Chipman, such agitation by the jet will always be avoided when blowing vertically because a far more powerful agitation of the bath caused by chemical reactions renders any agitation by the jet insignificant, regardless of the depth of penetration by the jet. For example, when asked:

> ". . . do you think anyone skilled in the art would have any difficulty in blowing in such a way as to avoid material agitation of the bath?"

Dr. Chipman replied:

> "He is going to blow in such a way to generate powerful chemical reactions which do a lot of agitating. He has to do this in order to operate the process. So he wouldn't have a bit of difficulty in setting up conditions where the chemical effects of CO evolution far over-shadow the effects of the direct agitation by the mechanical action of the oxygen stream." (R. 1064-65. See also *supra* II. E. (2) (a).)

As for the "localized reaction zone," Dr. Chipman defined such a zone as "the reaction in which the oxygen stream engages the metal."

The Court then inquired:

"It is anywhere the oxygen stream may engage the metal bath. Is that what you are saying?

[135] "A. Yes, your Honor." (R. 909.)

Dr. Chipman also testified that the localized reaction zone is a characteristic of the process which could not be avoided, even by blowing according to the teachings of Schwarz and Miles. Thus, at R. 1018, he was asked:

"Doctor, you have just admitted that if you blew according to Miles or according to Schwarz, so that you had penetration, you would have the hot spot in the cavity. That is correct, isn't it?

"A. Yes."

Also at R. 906-07, the following discussion occurred:

"Q. Well, do you mean that any time you jet oxygen onto a bath, you have in that fact alone answered this step of the claim?

"A. If a reaction occurs in the zone, yes.

* * *

"Q. I am trying to find out where the extent of the reaction zone is. Once more, suppose I am the manufacturer who wants to avoid this patent and I can avoid it by avoiding the localized reaction zone. Now, what do I do?

"A. You use another process.

"*The Court.* Use what?

"A. Another process. The localized zone is a characteristic of the process, and he cannot avoid it."

With regard to "high temperature," Dr. Chipman testified as follows:

"Q. . . . Now, do I understand from this that the hot spot develops at the bottom of the cavity made by the penetrating jet?

"A. All over the cavity.

"Q. And that occurs without regard to the depth of the cavity?

"A. Yes. The hot spot develops all over the cavity without regard to the depth.

[136] "Q. I take it that the hot spot you speak of there develops all over the cavity when you practice the teaching of Schwarz; is that so, Doctor?

"A. I think so.

"Q. You can't avoid it, can you?

"A. I don't think you can avoid it.

"Q. And it happens when you practice the teaching of Miles?

"A. Blowing oxygen onto and into the bath, you can't avoid the high temperatures." (R. 1016-17.)

With regard to the claim of a reaction-induced circulation, it is undisputed by the parties that a circulation of the molten metal bath down in the center could only be caused by chemical reactions and not the mechanical action of the jet. (E.g., defendant's main brief, p. 52.) Both Dr. Chipman and Dr. Elliott testified for plaintiffs that bottom damage in certain of defendant's tests involving deep penetration by the jet was caused by a downward moving stream of hot metal. (R. 635-36, 12,340-43.) However, if a steelmaker practicing

even deep penetration as taught by Schwarz and Miles has a down in center circulation which may result in bottom damage, then such a steelmaker must have a reaction induced circulation as claimed by the patent in suit, even though he is practicing the prior art. Additionally, the testimony of plaintiffs' witnesses with respect to the tremendous force of chemical reactions creating a circulation down in the center would tend to suggest that even deep penetration as taught by the prior art would result in such down in center circulation. (E.g., R. 3772-73; PX 267; R. 3801; PX 272.)

[137] Dr. Hauttmann, one of the patentees testified that he had no actual experience regarding deep blowing from above (R. 2519, 2522), and that he merely assumed that the circulatory movement of the bath as taught by the prior art was up in the center. (R. 2524.) He finally admitted that he did not know the actual direction of circulation under prior teachings or whether it was in fact the same circulation as produced by the method of the patent in suit, stating: "We have no data on that." (R. 2772.) It would seem, therefore, that the distinction between the claims of the patent in suit and the prior art practice may well be a purely verbal one. In this connection, it must be noted that plaintiffs had considerable opportunity, both before and during the trial of this suit, to conduct steelmaking experiments that would illustrate a distinction, if any, between the process as claimed in the patent in suit and the practice of steelmaking under the Schwarz and Miles teachings of deep penetration. However, plaintiffs admittedly failed to come forward with evidence of any such experiments. (R. 13,332-33.)

(4) CONCLUSION ON CLAIMS UNDER § 112

In sum, it appears to this Court that when the applicants were faced with the rejection of claims accurately stating what they regarded to be their invention as unpatentable over the prior art, they unwisely abandoned such claims and instead substituted new claims which were accepted by the Patent Office. The new claims failed to point out the actual invention of the patentees, and, in addition, certain portions of the claims were not given adequate or meaningful support by the specification. At trial, certain of plaintiffs' witnesses candidly interpreted the claims of the patent in suit as being so broad that any [138] commercial steelmaking operation involving vertical blowing would necessarily infringe even if the operation were following prior art teachings, although the language of the new claims was clearly intended to distinguish the prior art patents. Such claims, if allowed, would flout the patent law of the United States.

It is well-settled that valid patent claims cannot claim more than the actual invention of the applicant. *Lincoln Engineering Co. v Stewart-Warner Corp.,* 303 U. S. 545, 549 (1938); *Holstensson v. V-M Corp.,* 325 F. 2d 109, 122 (CA 6, 1963); *Plax Corp. v. Precision Extruders,* 239 F. 2d 792, 795 (CA 3, 1957). As Mr. Justice Story stated as early as 1822 in *Evans v. Eaton,* 20 U. S. 356, 430:

> ". . . it is clear that the party cannot entitle himself to a patent for more than his own invention; and if his patent includes things before known, or before in use, as his invention, he is not entitled to

recover, for his patent is broader than his invention."

It is equally well-settled that valid patent claims cannot claim more than the specification discloses. *Schriber-Schroth Co. v. Cleveland Trust Co., supra,* 305 U. S. 47, 57 (1938); *Application of Holmen,* 347 F. 2d 852, 855 (C.C.P.A. 1965); *Del Francia v. Stanthony Corp.,* 278 F. 2d 745, 747 (CA 9, 1960); *Texas Co. v. Globe Oil & Refining Co.,* 225 F. 2d 725, 735 (CA 7, 1955).

Moreover, it is well-recognized that claims are too broad when they cover the prior art and are not confined to an applicant's advance in the art. *United Carbon Co. v. Binney & Smith Co.,* 317 U. S. 228, 236 (1942); *Huntman Stabilizer Corp. v. General Motors Corp.,* 144 F. 2d 963, 967 (CCA 3, 1944); *In re Oakes,* 140 F. 2d 669, 671 (C.C.P.A. 1944); *Heyer v. Brenner,* [139] 242 F. Supp. 538, 540 (D.C. Dist. of Col., 1965). As Mr. Justice Jackson stated in the *United Carbon Co.* case, *supra,* at 236-37:

> "The statutory requirement of particularity and distinctness in claims is met only when they clearly distinguish what is claimed from what went before in the art and clearly circumscribe what is foreclosed from future enterprise. . . . An invention must be capable of accurate definition, and it must be accurately defined, to be patentable."

In this connection, the Supreme Court commented in *Merrill v. Yeomans,* 94 U. S. 568, 574 (1876):

> "It seems to us that nothing can be more just and fair both to the patentee and to the public, than that the former should understand and correctly describe just what he has invented, and for what he claims a patent."

Further, the Supreme Court stated in *General Electric Co. v. Wabash Appliance Corp.,* 304 U. S. 364, 369 (1938):

> "The limits of a patent must be known for the protection of the patentee, the encouragement of the inventive genius of others and the assurance that the subject of the patent will be dedicated ultimately to the public. The statute seeks to guard against unreasonable advantages to the patentee and disadvantages to others arising from uncertainty as to their rights. The inventor must 'inform the public during the life of the patent of the limits of the monopoly asserted, so that it may be known which features may be safely used or manufactured without a license and which may not.' The claims 'measure the invention.' "

The claims of the patent in suit do not measure the invention of the applicants; they do not accurately define or correctly describe just what the applicants invented; they do not find adequate support in the specification; and they do not clearly distinguish what is claimed from what went before in the art. Therefore, the claims do not meet the requrements of 35 U.S.C. § 112, and the patent in suit must be held invalid. 35 U.S.C. §282(3).

[140] III. CONCLUSION

The Court reaches its conclusion that the patent in suit is invalid reluctantly, not only because of the statutory presumption of validity but also because of the revolutionary nature of the invention disclosed in the specification. Revolutionary patents such as this one are entitled to a liberal construction. *Eibel Process Co. v. Minnesota & Ontario Paper Co.*, 261 U. S. 45, 63 (1923); *Cold Metal Process Co. v. Republic Steel Corp.*, 233 F. 2d 828, 837 (CA 6, 1956). However, even under a liberal construction of the patent in suit, the failure of the claims to focus on or limit themselves to the precise advance in the art by the patentees renders the patent invalid. Certain elements of the claims are simply not adequately supported by the specification to justify the granting of a patent monopoly in the broad language used. Morover, the claims take away from steelmakers the right to operate under certain prior art teachings if they choose.

It is not too much to require that the scope of patent monopolies be precisely defined and confined to the actual invention disclosed by the specification. Article 1, Section 8, of the United States Constitution gives Congress the power to secure to inventors the exclusive right to their actual discoveries, and no more. To grant an inventor a monopoly broader than the scope of his actual invention, even though that invention be revolutionary and fully disclosed in the specification of his patent, is not permitted by the Constitution or patent legislation as interpreted by the courts. *Holstensson v. V-M Corp., supra,* 325 F. 2d 109, 125 (CA 6, 1963).

Again it must be emphasized that it was not inevitable that such an outstanding invention as the oxygen steelmaking [141] process at Linz, Austria, should become the subject matter of an invalid patent in the United States. It is not the responsibility of the courts to remedy deficiencies in patent claims which might have been avoided by a more careful preparation and presentation to the Patent Office. Even liberal construction of patent claims does not extend so far.

In this Court's opinion, the Suess et al. patent in suit, No. 2,800,631, is invalid under 35 U.S.C. § 112 for failure of the claims to particularly point out and distinctly claim the subject matter which the applicants regarded as their invention. A judgment must, therefore, be entered for defendant, without, however, the allowance of attorney fees as requested under 35 U.S.C. § 285, which reads: "The court in exceptional cases may award reasonable attorney fees to the prevailing party." A case is not "exceptional" within the meaning of this provision unless the conduct of the party against whom attorney fees are sought may be characterized as unfair or vexatious, or involves bad faith or some other equitable consideration which makes it unjust that the prevailing party should be left to bear the burden of its own attorney fees. *Plymouth Rubber Co. v. Minnesota Mining & Mfg. Co.*, 203 F. Supp. 595 (D.C. Mass. 1962), aff'd, modified on other grounds, 321 F. 2d 151 (CA 1, 1963), cert. den. 375 U. S. 969 (1964); *Hyster Co. v. Hunt Foods, Inc.*, 263 F. 2d 130 (CA 7, 1959); *Rohr Aircraft Corp. v. Rubber Teck, Inc.*, 266 F. 2d 613 (CA 9, 1959). No such characterization of plaintiffs' conduct is even remotely justified.

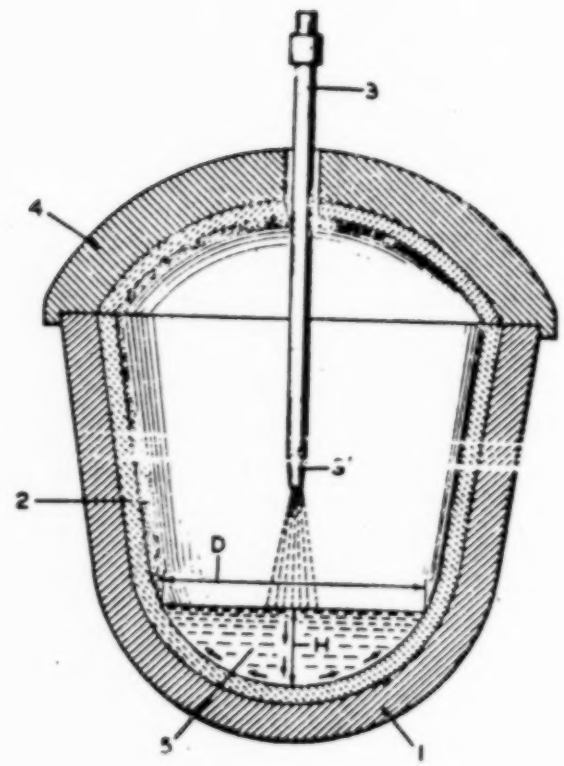
Of course this Court has considered all the issues raised by the parties in this litigation including the issues of infringement and misuse, and the Court has reached its conclusions [142] with respect to all issues in the case only after an intensive review of the entire record. A detailed study of the pertinent evidence was necessary, particularly with respect to the issue of infringement, because of the relevance of such a study to the question of validity as well. However, in view of the Court's holding of invalidity, it becomes unnecessary at this time to discuss the issues of infringement and misuse, those issues having become moot. *Bobertz v. General Motors Corp., supra,* 228 F. 2d 94, 101 (CA 6, 1955), cert. den. 352 U. S. 824 (1956). Such discussion would only serve to lengthen unduly this already protracted opinion.

The parties are invited to submit further proposed findings of fact consistent with this opinion. An appropriate order may be submitted.

RALPH M. FREEMAN [SGD.]
United States District Judge

DATED: July 6th, 1966.

July 23, 1957 T. E. SUESS ET AL 2,800,631
METHOD OF CARRYING OUT MELTING PROCESSES
Filed Nov. 18, 1955



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United States Patent Office

2,800,631
Patented July 23, 1957

2,800,631

METHOD OF CARRYING OUT MELTING PROCESSES

Theodor Eduard Suess, Luxemburg, and Herbert Trenkler, Robert Hansteaan, and Rudolf Rinesch, Linz (Danube), Austria; said Suess assignor to Vereinigte Österreichische Eisen- und Stahlwerke Aktiengesellschaft, Linz (Danube), Austria, a corporation of Austria

Application Nov. 16, 1955, Serial No. 547,233

2 Claims. (Cl. 75—60)

This invention relates to a process for the treatment of metallic or metal-containing materials with oxygen-containing gases, preferably high purity oxygen, and has particular relation to a process of this type in which fusible materials are treated at high temperatures with said gases. Still more particularly, the invention relates to a process for the refining of molten metal with high purity oxygen blown downwardly onto the surface of a bath of the molten metal.

The invention is particularly adapted to the refining of primarily hot metal charges, for example, molten pig iron, but it is also applicable to the production of refined metals from solid charges, such as solid pig iron for the production of steel, as hereinafter set forth. The invention is also characterized by the fact that the heat required for the refining of the molten impure metal is autogenous, being produced primarily by reaction of the oxygen gas with the impurities in the molten metal, although when utilizing solid charges of impure metal, the heat required for melting of the charge prior to refining is provided by combustion of a suitable fuel with the oxygen gas.

Processes for the utilization of high purity oxygen in the refining of molten metal charges, such as pig iron, have been suggested ever since the development of the original pneumatic process by Bessemer. Attempts to blow with high purity oxygen in a conventional Bessemer or Thomas converter through bottom tuyeres has resulted in the destruction of the refractory bottom within the short time of one heat. On the other hand, high purity oxygen refining processes have been previously proposed in which the oxygen is directed onto the molten metal bath surface in the form of a jet or jets issuing from tuyeres positioned in the wall of the refining vessel above the melt line. In such processes, the horizontal velocity component of the oxygen jet at the melt surface causes the development of excessively high temperatures above and at the melt-slag interface on the side of the vessel opposite the tuyeres or oxygen jet inlet so that a rapid deterioration of refractory occurs. In addition, with such an inclined oxygen jet, a loss of oxygen efficiency results due to deflection of the gas from the melt surface and burning of a large proportion (40–50%) of the evolved carbon monoxide to carbon dioxide above the melt, which is further undesirable in contributing to the short refractory life. In addition, the heat produced by high purity oxygen-molten metal reactions is more than sufficient to provide the heat necessary for completion of the refining reactions to the desired steel analysis, and this large amount of additional heat developed within the refining vessel due to carbon monoxide combustion is undesirable. Further, in the utilization of high purity oxygen as the refining medium, the reduction in oxygen efficiency resulting from this combustion of the carbon monoxide with a portion of the oxygen feed cannot be tolerated.

Accordingly, it is recognized that the application of such processes, in which the molten materials, for example pig iron, are treated in refining devices provided

with refractory linings are severely limited due to the extremely high temperatures developed by reaction of the high purity oxygen gas with the molten metal and the short life of the refractory linings when exposed to such temperatures. This is particularly true in those processes, such as production of steel, in which chemical reactions capable of causing corrosion of the refractory lining take place. Thus, in a device provided with refractory lining, such as a converter in the previously proposed processes when high purity oxygen is blown to the surface of a bath of molten pig iron, with or without a slag cover, combustion of the impurities in the metal, and also iron itself result in such extremely high temperatures that the refractory lining is attacked and damaged to such extent that it must be removed after a short period of use. The refractory materials known at present are unable to resist attacks and stresses of this kind unless the lining is protected by the application of particular conditions from direct exposure to the strong heat developed by the high purity oxygen-molten metal reactions. Accordingly, although the advantages of molten metal refining with high purity oxygen have been recognized, particularly with respect to the reduced nitrogen ballast compared to the air blown pneumatic refining processes, there remains no economical, commercially feasible process for refining of molten metal with high purity oxygen capable of providing long refractory life and high oxygen efficiency. In particular, the deficiencies of the proposed processes, emphasize the lack of a high purity oxygen refining process for molten pig iron having the aforementioned advantages to provide an economical, commercially feasible process for production of refined steel at least equal in quality to that produced by the well known basic open-hearth process from pig iron of widely varying chemical compositions.

It is accordingly one of the main objects of the present invention to provide a process for refining molten metals by surface blowing with high purity oxygen, in which, owing to the particular conditions employed, the refractory walls of the apparatus utilized in carrying out the process are protected from undue corrosion by the excessively high temperatures developed and the chemical reactions taking place at such temperatures.

Another object of the present invention is to carry out the treatment of molten metals, and other molten materials by surface blowing with high purity oxygen in such a manner that the reactions of the oxygen gas with the constituents of the molten bath and the resulting high temperatures, to the extent possible, are limited to an oxygen jet impingement area removed from the refractory lining of the reaction vessel.

It is also a primary purpose and object of this invention to provide a process for the refining of primarily hot metal charges, that is, predominantly molten pig iron, with high purity oxygen gas in which controlled refining at substantially theoretical oxygen efficiency is accomplished.

A further object is to provide a process for refining of molten pig iron with a surface blown high purity oxygen jet in which an exceptionally high refractory life is obtained.

The invention also has as its object to provide a process of surface blowing molten pig iron with high purity oxygen in which the refining reactions and oxygen impingement on the melt surface are controlled in a manner such that over-oxidation of the molten pig iron bath is essentially avoided.

It is still another object of the invention to provide a high purity oxygen refining process which is applicable to pig iron of widely varying chemical compositions including in particular pig iron of analyses used in or

linary basic open-hearth practice, as well as those of higher silicon and phosphorus content required for blowing in the acid Bessemer and basic Thomas converter processes to produce steels having analyses and qualities at least comparable to that of basic open-hearth steels. Another object of the invention is to provide a high purity oxygen refining process for production of steel of excellent quality at a high rate of production, substantially comparable to Bessemer or Thomas converter practice, for example, a blowing time of from 15 to 30 minutes for charges of from 30 to 40 tons to carbon end points of 0.05% or below.

Further objects and advantages of the invention will be apparent from the following detailed description of the process and the appended drawing.

The process of the invention generally comprises refining the molten metal in a converter type or other suitable vessel with a high purity oxygen jet impinging vertically or approximately vertically on the melt surface substantially at the central portion thereof by means of a blast nozzle or other suitable jet producing means under controlled conditions, hereinafter defined, to supply to the molten metal the required amount of oxygen for completion of refining within a predetermined time, and to produce autogenous heat sufficient to insure completion of the refining and adequate temperature in the refined charge for subsequent handling.

It has been found that by suitable arrangement of the nozzle or jet producing device, and operation thereof for the supply and introduction to the molten metal of the high purity oxygen gas, suitable design of the refractory lined refining device in which the process is conducted, and proper use of amounts of materials charged, the foregoing advantages are obtained, including a very efficient protection of the refractory lining.

According to the process of the invention, the high purity oxygen jet is blown vertically, or approximately vertically upon the central portion of the surface of a bath of the molten metal, the jet having a diameter and static pressure at the point of origin, that is, at the blast nozzle or other jet producing means, and the point of origin (blast nozzle) being spaced from the bath surface, such that direct contact of the oxygen jet and the molten metal is established and maintained throughout the refining period without deep penetration of the molten metal bath by the jet. In so operating, the area of jet impingement is controlled to produce a relatively confined zone of direct oxygen to molten metal contact with respect to the total surface area of the bath. It has been determined in application of the present invention to the refining of predominantly molten pig iron charges by means of high purity oxygen, that the jet blown onto the surface of the molten iron, as above described, under a relatively low static pressure at the point of origin, for example, at the overhung blast nozzle, of from 5 to 25 atmospheres (about 75 to 375 pounds per square inch), preferably at about 8 to 12 atmospheres (about 115–175 pounds per square inch), with the jet diameter at the point of origin or blast nozzle being about 1 millimeter (1/25 inch) per ton of charge, and with the point of origin or blast nozzle spaced from the bath surface from at least 150 millimeters (about 6 inches) up to about 2000 millimeters (about 80 inches), produces a sufficiently high reaction velocity of the oxygen with the bath constituents to insure the development of autogenous heat at a rate sufficient to provide the heat required for completion of the refining in a minimum of time, consistent with controlled temperature and control and development of other necessary and required process conditions, such as fluid slag, avoidance of overoxidation (undue loss of iron to the slag), and avoidance of slopping. The process conducted under these conditions avoids a deep penetration of the oxygen gas into the molten bath which seriously impairs refractory life at the bottom of the refining vessel. In addition, the impingement area of the high purity oxygen on the central portion of the bath isolates the refractory walls of the refining vessel from the extremely high temperatures which are developed by the direct reaction of the oxygen and the molten metal.

It has also been found, according to the invention, that the utilization of suitable design of reaction vessel and the use of the proper amount of material charged results in a ratio of the depth of the bath to the surface area of the bath which augments the protection afforded to the refractory lining of the refining vessel and is also beneficial to the progress of the refining reactions to produce finished steels of low impurity content comparable to those produced by the basic open-hearth process. In carrying out the process of high purity oxygen refining of a molten bath of pig iron, the refining vessel is of such design and the charge is of such amount that the ratio of the depth of the molten bath in meters to the surface area of the molten bath in square meters should be from about 1 to 5 to about 1 to 28 in refining vessels of various design or in terms of the ratio of depth to diameter of a circular bath between 1:2.5 and 1:19. In other metallurgical processes to which the present invention is adapted substantially similar ratios may be used.

Although it is not intended to limit the present invention to any specific theory of action or mechanism, it is believed that application of the oxygen jet substantially vertically or approximately vertically upon the central portion of the bath surface brings about a flow in the molten metal from the center of the surface of the bath downwardly and then along the bottom of the refining vessel, and upwardly at the sides of the vessel to the surface of the bath, so that portions of the unrefined metal are continuously presented to a localized center of direct oxygen reaction with the bath metal, while reacted or oxidized portions of the bath move away from this reaction center. This apparent circulation of the molten material is facilitated by shaping of the bottom of the device in its refractory lining in a uniformly curved design, preferably hemispherical or similar shape, so as to offer the minimum of resistance to the circulation.

Due to the very high affinity of oxygen for iron, initial contact of the high purity oxygen jet with the molten metal bath causes a rapid combination of oxygen and iron to form FeO in the confined central reaction zone. This is demonstrated by ignition of the oxygen and the propagation of a visible flame within the first minute of blowing. This reaction, together with oxidation of impurity elements, such as silicon and manganese, develops extremely high temperatures in the zone of direct oxygen contact with the molten metal which approach the boiling point of iron, as demonstrated by the evolution of a fume containing iron oxide and manganese oxide. A portion of the iron oxide goes to the slag with the other oxidized elements and a portion diffuses into the bath under the influence of the bath circulation, so that within the first three minutes of the blowing vigorous carbon combustion is initiated due to the high temperatures developed by these reactions. The ensuing reaction of carbon with the FeO and directly with the oxygen gas in the confined direct oxidation zone causes rapid formation of carbon monoxide and the formation of this CO causes a strong boil or agitation of the bath, which augments the bath circulation to continuously present unrefined metal to the oxygen gas reaction zone and to create a slag-metal emulsion. The oxygen jet thus contacts the emulsion of bath and slag components which presents a larger reaction surface and causes the refining reactions to progress rapidly although the oxygen jet does not penetrate deeply into the molten metal bath and is confined to an impingement area at the central portion of the bath surface. This vigorous boiling action is opposed by the pressure of the oxygen jet only in the area of impingement, and outside of this area it represents primarily endothermic

reduction of FeO by carbon to form the evolved carbon monoxide, which reaction thus effectively encompasses the zone of direct oxygen reaction at which the highest temperatures prevail affording a maximum measure of protection to the refractory lining of the refining vessel.

In conducting the process in the manner set forth above, the advantage of exceptionally high refractory life is obtained. For example, in refining of pig iron having the following chemical composition: carbon 3.8–4.2, silicon 0.6–1.3, manganese 1.4–2.2, phosphorus 0.120–0.250, and sulfur 0.045 max., and a slag having the following composition SiO_2 12–17%, CaO 38–44%, MgO 5–10%, MnO 9–13%, P_2O_5 1.2–1.8%, and Fe 12–17%, in a 30 ton converter, the average durability of the refractory is over 200 heats (foregoing in percentages by weight). By comparison, in basic Bessemer practice utilizing air rather than high purity oxygen, the removable converter bottom must be relined after only 35 to 60 heats. In addition, the refractory life obtainable by the process of the invention surpasses that obtained in normally operated open-hearth practice in that in refining of a normal charge by basic open-hearth about 36 lbs. of refractory brick is consumed per ton of steel produced to which must be added some 40 pounds of sintered dolomite for fettling operations, whereas total refractory consumption in the instant process is only about 24 lbs. per ton of steel produced. This advantage is even greater when compared to oxygen lancing in an open-hearth which accelerates refractory consumption.

The further advantage of high oxygen efficiency is obtainable according to the process of the invention when the oxygen jet impinges on the central portion of the molten bath surface from directly above, that is, approximately vertically. Oxygen efficiencies calculated on the basis of total oxygen input compared to oxygen consumed in the bath reactions is approximately 95%. This is demonstrated by an average oxygen consumption of only 57 normal cubic meters (measured at standard conditions of temperature and pressure) per ton of steel including oxygen consumption for heating the converters after relining. This compared with calculated or theoretical oxygen requirements for the refining of the various pig irons known to steel analyses set forth below represents about a 95% efficient utilization of oxygen. In addition, analyses of waste gases effluent from the converter indicate that the carbon in the instant process burns almost 100% to carbon monoxide, the analyses showing on the average over 90% CO and less than 10% CO_2, indicating that the oxygen input is not lost by burning with the carbon monoxide above the melt within the refining vessel, as in the case of low angle impingement from tuyeres positioned in the side walls of the refining vessel. Moreover, this is a distinct advantage in the instant process, since the reaction of the oxygen with the melt provides more than sufficient heat for the refining, and additional heat by burning of the carbon monoxide to carbon dioxide above the melt is to be avoided. The potential heat units in the effluent carbon monoxide may be utilized in various ways by subsequent burning.

As above mentioned, it is a characteristic of the process of the invention that in the confined zone of direct oxygen reaction at the surface of the molten metal bath, the oxidation products of the impurities in the pig iron, such as silicon and manganese, as well as the oxidized iron form an early fluid slag which is always very rich in oxides, that is, highly oxidizing. With the formation of the slag-metal emulsion, the iron oxide reacts with the carbon present in the bath, primarily outside of the direct oxygen-metal reaction zone, and since such slag-metal reactions are endothermic, the molten bath is maintained cooler in the vicinity of the walls of the refining vessel or converter. For example in the formation of one kg. of FeO, by direct oxidation with the oxygen jet and absorbed as iron silicate into the slag, 80 kg. calories of heat are developed. An equal amount of heat is absorbed outside

of the confined central zone of direct oxidation as the FeO (as silicate) is reduced by the carbon in the bath, as one example of slag metal reactions occurring during the blowing.

This formation of an early highly oxidizing fluid slag is of particular value in basic refining when the process is applied to pig iron of analyses used in ordinary open-hearth practice, which would not be amenable to refining by either the acid Bessemer process due to the phosphorus content, or the basic Thomas process due to the lack of sufficient phosphorus. With the rapid heating of the slag cover and metal bath, the proper amounts of lime or lime supplying substance, such as limestone, may be added at the beginning of the blow and during the blow to insure formation and maintenance of a slag of sufficient basicity. Thus, the early fluid, basic and highly oxidizing slag formed provides an accelerated rate of phosphorus and sulfur removal from the bath, leaving the finished steel very low in both elements. With normal open-hearth pig irons having phosphorus contents ranging from about 0.1–0.35%, and even higher, e. g., 0.85% P, and with correct lime additions, final phosphorus contents not higher than about 0.025% and as low as 0.010% are obtained by the time the carbon end point is reached with only a single slagging operation. With sulfur contents in the pig iron of from 0.045 to 0.08%, the sulfur is decreased to 0.02–0.025%, and on the lower range of sulfur in the pig iron to values as low as 0.012%. In usual operations, from 1 to about 4.5% lime is charged to obtain the foregoing result, depending upon the phosphorus content in the pig iron. In addition, all of the lime requirement may be added during initial charging before blowing is started, particularly where the silicon content of the pig iron, which is one of the first oxidized elements, is sufficiently high. On the other hand, the lime may be charged in increments during the blow, but with a sufficient amount initially charged to provide a basicity adequate to absorb the phosphorus.

In the normal range of phosphorus in pig iron of basic open-hearth quality from about 0.1 to 0.35%, the required slag volume including the lime charge is advantageously much lower than the slag volume in the bottom blown basic Thomas process. The iron content of the slag varies from about 9 to 18%, with generally higher FeO content in the slag at higher phosphorus contents in the pig iron, and also at lower manganese contents. Accordingly, the lower percentage of slag, for example, 11 to 12% compared to about 22% in the Thomas process results in comparable or lower total iron content lost to the slag, even though the FeO content of the slag may be higher than the usual 10% in the basic Thomas process.

The process in its preferred embodiment utilizes high purity oxygen, by which the term is meant oxygen gas analyzing at least 97% O_2. For minimum nitrogen content in the finished steel of at least 98% oxygen and preferably 99% or higher should be utilized. The frequency curves based on produced steel analyses indicate that oxygen of at least 98% purity provides a peak or maximum at a nitrogen content of from 0.002 to 0.003%, with 95% of all heats blown showing a nitrogen content of 0.004% or less.

The vigorous boil, above mentioned, continues up to the carbon end point, and together with the induced circulation of the bath metal toward and away from the central zone of direct oxygen reaction, effectively counteracts any tendency to overoxidation of the bath. When the flame dies and carbon combustion is completed, the bath becomes relatively quiet and intimate contact between slag and metal bath ceases. The turbulence of the bath and slag due to the oxygen stream impinging from directly above is insufficient to cause continuance of oxygen-metal reactions. As a result, steels blown by the process of the invention do not suffer from the deteriorating effects of high oxygen (FeO) contents. Direct oxygen determination by the hot extraction method yielded oxygen con-

tents of 0.04% maximum for heats that were blown to a carbon end point of from 0.05 to 0.10% C. Thus, the oxygen content of steels produced by the high purity oxygen blowing process compare very favorably with oxygen contents of basic open-hearth steel in the same carbon range, and are definitely lower in oxygen content than bottom blown Bessemer steels using air, oxygen enriched air, oxygen and steam, or other gas mixture.

As in the basic Bessemer process, the silicon is rapidly eliminated. However, in contrast to the basic Bessemer process, the use of high silicon charges presents no problem due to the fact that slopping is not encountered in the process of the invention to any degree similar to that in the bottom blown Bessemer practice. In fact, higher silicon pig irons actually are advantageous in the high purity oxygen blowing due to the heat producing effect of this element in the early stages of the blow with the result that higher scrap charges can be made in the process.

Regarding scrap additions, the process advantageously may utilize scrap charges of up to about 30%, depending primarily upon the silicon content of the pig iron, and also on the temperature of the hot metal charge. For lower ranges of silicon, such as 0.3 to 0.7% scrap charges of from 10 to 15% are permissible. With silicon in amounts from 1 to 1.2%, scrap charges of 20 to 25% may be utilized.

In general, the manganese content of the fully blown metal and of the slag increases with the total manganese content (pig iron and scrap). However, it is a characteristic of this oxygen steel making process that the high temperatures developed in the reaction zone between the bath metal and the slag cause a rereduction of manganese from the slag into the bath during the latter portion of the refining period. In the last minutes of the blow, the manganese content in the bath again decreases as the carbon drops to its final value, that is, at a normal end point of 0.04–0.06. Accordingly, the manganese content in the finished steel and in the slag is subject to some control, and is governed by slag composition and volume, temperature and final carbon content. With the use of a minimum amount of slag rich in iron oxide, for example only 70 kg. per ton of steel, the amount of loss of manganese to the slag by burning may be considerably reduced. As above mentioned, extensive tests have shown that the amount of slag can be kept considerably lower than the conventional pneumatic process, such as the Bessemer and Thomas processes. Under these conditions of high developed temperature in the refining process and low slag volume with high iron oxide content, a finished steel containing manganese in quantities at least 10 times the amount of carbon, for example, 0.6 to 0.8 Mn at carbon end points of 0.05% are obtainable. Accordingly, it is possible to pour rimming steels down to relatively very low carbon contents without any addition of manganese and deoxidizing agents. Under actual operating conditions the best practice for production of standard grades is to refine down to 0.06–0.08% C and to recarburize in the ladle. This practice results in a manganese content of from 0.6 to 0.8 and eliminates the necessity for manganese additions to conform with the usual analysis specifications. The above manganese content easily compares with the conventional composition of rimming low-carbon open-hearth steels, in fact such analyses are near the upper limit of the range. It is also possible to catch the heat at higher carbon contents, so that the resulting content in manganese will be of a higher order than is normally encountered in rimming open-hearth steels of identical carbon content. Thus, it is possible to produce rimming low carbon high purity oxygen blown steels of a predetermined strength which is based on an inherently higher manganese content of the heat.

It has also been found that a steel containing 0.1% carbon and as high as 1.5% manganese may be obtained, for example by the addition of ordinary blast furnace

ferromanganese, e. g., 15 kg. of 48% blast furnace ferromanganese per ton suffices, and results in an increase of about 0.05% in the carbon content. In normal steel making operations it was not previously possible to obtain such steels without the use of expensive refined ferromanganese products. Steels of such analyses, not only exhibit increased toughness and yield strength but other properties, such as pressure weldability, are improved.

To exemplify the high manganese recovery in the steel without ferromanganese additions after the blow, the results of the following heats are provided. As indicated above, since the manganese content, under otherwise equal conditions, increases in the finished steel with increase in pig iron, it is to be noted that particularly high manganese content pig irons were employed. Nevertheless, it is evident that due to the extremely high temperatures developed in this high purity oxygen process, a manganese recovery is possible which cannot be reproduced in known processes.

Heat No. 1.—Pig iron analysis: 4.16% C, 3.02% Mn, 0.14% Si, 0.074% P, 0.040% S. Last converter control test (without ferromanganese or deoxidizers): 0.09% C, 0.96% Mn, 0.005% Si, 0.039% P, 0.013% S, 0.007% N_2.

Heat No. 2.—Composition of pig iron: 4.30% C, 3.24% Mn, 0.33% Si, 0.072% P, 0.034% S. Last converter control test (without ferromanganese or deoxidizer): 0.08% C, 1.02% Mn, 0.005% Si, 0.037% P, 0.010% S, 0.004% N_2.

Heat No. 3.—Composition of pig iron: 4.21% C, 2.88% Mn, 0.27% Si, 0.076% P, 0.044% S. Last converter control test (without ferromanganese or deoxidizer): 0.07% C, 0.93% Mn, 0.005% Si, 0.037% P, 0.012% S, 0.004% N_2.

From the foregoing test, it may be seen that manganese recovery at least 10 times as high as the final carbon content in the finished steel is obtainable by the process of the invention utilizing pig iron having manganese on the order of 3%.

In regard to output, the combustion of the impurities of the pig iron and the iron content of the slag total a loss of about 8.0% with an additional 0.8% of iron lost in the dust fume from the process. With mechanical losses averaging about 0.8%, the percentage recovery of the refining process is approximately 90%, comparable to the yield obtainable by the basic open-hearth process. In the progress of the high purity oxygen blowing, up to about the eighth minute, oxidation of the iron progresses under formation of comparatively large amounts of FeO, which, as above stated, promotes a desirable quick liquefaction of the basic lime slag. At this stage in the blow, the slag shows maximum values of from 25–30% FeO. In the further course of the process reduction of Fe from the slag occurs which continues until the carbon content of the bath of about 0.07% is reached. The FeO in the slag decreases to about 10–12%. On further removal of carbon, the FeO in the slag again increases so that in the final slag generally an iron content averaging 14% is obtained, and only at very low carbon heats does the iron content exceed this value.

Under these known metallurgical conditions above set forth, the total oxygen requirement is calculated on the basis of oxygen pick-up of the heat during the refining period. Summation of these oxygen gas volumes required for the oxidation to complete refining indicates substantially a straight line function on oxygen input, and corresponding to this relative constancy of oxygen input, the oxygen pick-up proceeds uniformly during the blow. The oxygen input is maintained at a rate such that the speed of the refining process insures satisfactory rereduction of FeO from the slag, in the manner set forth above. In actual practice, based on experience in operation of 30 ton converters, oxygen feed rates may be maintained such that depending upon pig iron analysis, amount of scrap addition and desired finished steel analysis, the

refining to usual carbon end points on the order of 0.05% C is completed in from about 15 to about 30 minutes, preferably 18 to 22 minutes. Flow rates of from about 4000 to 8000 cubic meters of oxygen per hour are representative of the oxygen input under these conditions.

In such exemplary commercial practice with 30 ton converters charged to 35 to 36 tons, oxygen pressures at the blast nozzle of about 8 to 10 atmospheres and oxygen jet or blast nozzle diameters of from about 27.5 to 35 millimeters (1.1 to 1.4 inches) with nozzle spacings varying from 25 to 50 inches (about 650 to 1250 millimeters have been used, the preferred spacing being from 30 to 40 inches (about 750 to 1000 millimeters). In general, it may be stated that as the oxygen pressure and nozzle diameter are increased, the nozzle spacing is also increased, for example, as the capacity of the refining vessel and total charge is increased. Under these conditions, deep penetration of the molten metal bath is avoided, while the necessary displacement of the slag cover to maintain direct oxygen to molten metal contact is insured. However, in the unusual circumstances of an abnormally stiff slag cover, the blow may be initiated using mechanical means for penetrating the slag cover to establish oxygen to metal contact.

It is to be noted, that in certain instances particularly where the rate of oxygen input is relatively high, that is, the total blowing time is in the lower portion of the range above stated, the pressure of the oxygen jet at the blast nozzle may be reduced in the last few minutes of the blow to reduce the rate of oxygen input, which is beneficial in supporting the inherent characteristic of the process in regard to avoidance of over-oxidation of the heat. Due to this characteristic of the process, it is generally unnecessary to utilize any deoxidizing agents such as ferromanganese and ferrosilicon in the production of semi-killed steels, and only in the production of killed steels are the conventional deoxidizers employed.

The process has as one of its major advantages the applicability to pig iron of analyses used in ordinary open-hearth practice, which would not be amenable to refining by either the acid Bessemer process or the basic Thomas process. In addition, the process is fully applicable to pig irons having analyses of the type which are normally utilized in either the acid Bessemer or basic Thomas processes. Typical illustrations of the following pig irons and the finished steels produced therefrom indicate that the process produces steels comparable to open-hearth quality from pig irons of widely varying phosphorus and silicon contents.

(1) 4.0% C, 1.5–2.0% Mn, 0.7–1.2% Si, 0.1–0.24% P, 0.05% S, and 0.01% N blown to a finished steel of the following analysis: 0.06% C, 0.35% Mn, 0.00% Si, 0.026% P, 0.025% S, and 0.0025–0.0035% N (oxygen about 98%).

(2) Pig iron analyzing 3.5–4.25% C, 1.4–3.2% Mn, up to 0.3% Si, 0.06–0.1% P, 0.04–0.07% S, and 0.01% N from which steel of the following analysis is obtained: 0.06% C, 0.35% Mn, 0.00% Si, 0.01–0.02% P, 0.022% S, and 0.001–0.002% N.

(3) Illustrative of a grade of pig iron falling between that of normal open-hearth analysis and basic Bessemer pig iron is the following: 3.61% C, 2.16% Mn, 0.46% Si, 0.156% P, 0.062% S. Blowing of such a charge of rather unfavorable chemistry by the process of the invention yielded a steel of the following composition: 0.04% C, 0.15% Mn, 0.0% Si, 0.014% P, 0.045% S. Clearly, such a pig iron would be definitely unsuitable for basic Bessemer (Thomas) process refining, and would also present considerable difficulty if used for open-hearth refining.

The accompanying drawing diagrammatically illustrates a device for carrying out the present invention. In this drawing, reference numeral 1 denotes a metallic wall and 2 the refractory lining of the refining vessel. An oxygen supply lance 3 is centrally positioned and overhung above the charge and is provided with a nozzle

3' for the introduction of the oxygen gas, inserted in an opening of the cover 4. The material charge, including molten pig iron, melted scrap, and slag forming additions, such as limestone, is indicated at 5 and the depth and diameter of the upper surface of the molten bath in the quiescent state are denoted by H and D, respectively. The lance 3 is retractable, and is provided with water cooling ducts and connections (not shown). The cooling water in actual practice is supplied to the lance at a pressure of from 4 to 6 atmospheres and the normal flow rate is about 36 to 40 cubic meters per hour. Under such conditions the temperature of the cooling water increases from approximately 14° centigrade input to a maximum of about 30° centigrade in the effluent from the lance.

In the preferred commercial practice of the invention, a converter shaped vessel with an open mouth is usually provided, through which the lance is inserted into and retracted from operating position, as indicated in the example set forth below. In this manner, suitable gas take off devices may be positioned at the throat of the converter type vessel to collect the off gases and separate the particulate fume therefrom.

The following is a detailed description of a typical operation of the process, which is not to be regarded as a limitation on the invention, but rather as a complete specific embodiment thereof.

Example 1

A closed bottom converter of normally 30 tons (metric) capacity is charged with a total of about 36 tons of metal through an open mouth. The oxygen lance is inserted through the mouth of the converter to the adjusted distance above the melt surface. The diameter of the surface of the bath with such a charge is about 5 meters and the depth of the bath about 1 meter. A typical cycle of operations is given below on a time table basis.

	Hours
7100 kg. plant return scrap charged to converter	0
29,600 kg. pig iron poured from mixer into converter having an analysis as follows: 4.04% C, 0.99% Si, 1.73% Mn, 0.153% P, and 0.045% S	0.08
Addition of 850 kg. limestone and 60 kg. bauxite	0.10–0.13
Introduction of nozzle, oxygen jet initiated at a nozzle pressure of 10 atmospheres (147 p. s. i.) with a nozzle spacing above the bath of 1000 millimeters	0.15
850 kg. limestone and 200 kg. rolling mill iron slag added	0.16
750 kg. limestone chips added in five parts of 150 kg. each	0.22–0.28
Oxygen pressure reduced to 8 atmospheres	0.30
Mouth flame transparent, nozzle withdrawn, oxygen supply turned off—end of blowing time at 19 minutes	0.34
Converter contents sampled and analyzed as follows: 0.05% C, 0.00% Si, 0.31% Mn, 0.024% P, 0.02% S	0.35
Slag drawn off	0.35–0.39
150 kg. Spiegel iron added to contents of converter	0.39
Slag remaining in converter stiffened with 30 shovelfuls of limestone	0.39–0.42
Steel poured into pan, temperature measured at 1575° C., 6 kg. electroflour added to pan	0.42–0.45

Final test analysis on pouring into ingot mold was: 0.07% C, 0.32% Mn, 0.022% P, 0.020% S, 0.0035% N. Oxygen consumption 1950 cubic meters. This oxygen consumption is about 54 cubic meters (measured at standard conditions) per ton and compares with a theoretical oxygen requirement of 51 cubic meters (measured at standard conditions), and therefore indicates an oxygen efficiency of 95%.

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The process of the present invention may be also applied to the production of metals, for example, production of steel, from solid starting materials. In the production of steel, pig iron and scrap iron, and if desired certain alloys and fuels, such as coal or wood, are introduced into the refining vessel. As materials for producing heat for melting, coke, ferrosilicon, calcium carbide, aluminum alloys and the like, which are converted into slag or gaseous products at the prevailing refining temperatures can be added. The total amount of the starting material mixture may be introduced as a single charge prior to initiation of the melting, or may be gradually fed in small incremental amounts. Sufficient fuel should be present for producing the combustion necessary to provide the heat of fusion of the solid charge. After ignition of the fuel, melting of the initial mixture is brought about by the action of the oxygen jet.

The melting procedure is started by means of an ignited body which is introduced immediately prior to the initiation of blowing of the oxygen jet, and is preferably positioned at that portion of the solid charge where the oxygen jet comes in direct contact therewith.

Thus, according to the present invention, a steel may be produced with a minimum consumption of fuel, for foundries or rolling mills, by melting the iron to be converted into steel with low grade fuel and a high purity oxygen jet blast, for example, in cupola furnace, or in a converter type vessel itself, and subjecting the thus melted solid charge to high purity oxygen refining in the above described manner in a suitable refining vessel, such as a converter. In carrying out such a melting and refining treatment with high purity oxygen, the energy consumption is extremely low, amounting to only 100 cubic meters of oxygen (measured at standard conditions) per ton of steel produced. Of course, as indicated above in the refining of primarily hot metal charges constituting pig iron with analyses as set forth above to refine steels of 0.05% carbon content and analyzing as above indicated, the average oxygen consumption is only about 57 cubic meters per ton (measured at standard conditions).

The present process of surface blowing with high purity oxygen is also applicable to the desulfurization of copreous materials and to the production of glass in the converter with the use of sodium chloride. Furthermore, the process is applicable to the treatment of blast furnace slag to the elimination of sulfur and conversion of slags into melted cement or glass-like materials of the type used for the manufacture of slag wool.

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This application is a continuation-in-part of my copending application Serial No. 206,147, filed January 16, 1951, now abandoned. It will be understood that the present invention is not limited to the specific materials, steps and other specific details described above and may be carried out with various modifications without departing from the scope of the invention as defined in the appended claims.

We claim:

1. Method of refining molten impure iron in the presence of a slag in a vessel having a refractory lining by blowing with oxygen, which comprises discharging a stream of oxygen vertically downwardly through the slag layer onto and below the surface of the bath at the central portion thereof, to an extent to avoid material agitation of the bath by the oxygen stream, the contact of the oxygen with the bath resulting in reaction of the oxygen with a portion of the iron and with the oxidizable impurities of the bath in a localized reaction zone spaced a substantial distance from the refractory lining, the reactions in said zone resulting in refining of the iron and gas evolution and in the production of high temperature in the reaction zone away from the refractory lining, said reaction producing a circulatory movement in the molten metal, which circulatory movement brings those portions of the molten metal bath which are remote from the reaction zone into the reaction zone whereby those portions are subjected to said reaction with minimum injury to the refractory lining.

2. The gaseous oxygen process set forth in claim 1 in which the oxygen is blown into said vessel under pressure in a range between about five and about twenty-five atmospheres above normal atmospheric pressure.

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METHOD OF CARRYING OUT MELTING PROCESSES

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SPECIFICATION

This invention relates to a process for the treatment of metallic or metal-containing materials with oxygen-containing gases, preferably high purity oxygen, and has particular relation to a process of this type in which fusible materials are treated at high temperatures with said gases. Still more particularly, the invention relates to a process for the refining of molten metal with high purity oxygen blown downwardly onto the surface of a bath of the molten metal.

The invention is particularly adapted to the refining of primarily hot metal charges, for example, molten pig iron, but it is also applicable to the production of refined metals from solid charges, such as solid pig iron for the production of steel, as hereinafter set forth. The invention is also characterized by the fact that the heat required for the refining of the molten impure metal is autogenous, being produced primarily by reaction of the oxygen gas with the impurities in the molten metal, although when utilizing solid charges of impure metal, the heat required for melting of the charge prior to refining is provided by combustion of a suitable fuel with the oxygen gas.

Processes for the utilization of high purity oxygen in the refining of molten metal charges, such as pig iron, have been suggested ever since the development of the original pneumatic process by Bessemer. Attempts to blow with high purity oxygen in a conventional Bessemer or Thomas converter through bottom tuyeres has resulted in the destruction of the refractory bottom within the short time of one heat. On the other hand, high purity oxygen refining processes have been previously proposed in which the oxygen is directed onto the molten metal bath surface in the form of a jet or jets issuing from tuyeres positioned in the wall of the refining vessel above the melt line. In such processes, the horizontal velocity component of the oxygen jet at the melt surface causes the development of excessively high temperatures above and at the melt-slag interface on the side of the vessel opposite the tuyeres or oxygen jet inlet so that a rapid deterioration of refractory occurs. In addition, with such an inclined oxygen jet, a loss of oxygen efficiency results due to deflections of the gas from the melt surface and burning of a large proportion (40-50%) of the evolved carbon monoxide to carbon dioxide above the melt, which is further undesirable in contributing to the short refractory life. In addition, the heat produced by high purity oxygen-molten metal reactions is more than sufficient to provide the heat necessary for completion of the refining reactions to the desired steel analysis, and this large amount of additional heat developed within the refining vessel due to carbon monoxide combustion is undesirable. Further, in the utilization of high purity oxygen as the refining medium, the reduction in oxygen efficiency resulting from this combustion of the carbon monoxide with a portion of the oxygen feed cannot be tolerated.

Accordingly, it is recognized that the application of such processes, in which the molten materials, for example pig iron, are treated in refining devices provided with refractory linings are severely limited due to the extremely high temperatures developed by reaction of the high purity oxy-

gen gas with the molten metal and the short life of the refractory linings when exposed to such temperatures. This is particularly true in those processes, such as production of steel, in which chemical reactions capable of causing corrosion of the refractory lining take place. Thus, in a device provided with refractory lining, such as a converter in the previously proposed processes when high purity oxygen is blown to the surface of a bath of molten pig iron, with or without a slag cover, combustion of the impurities in the metal, and also iron itself result in such extremely high temperatures that the refractory lining is attacked and damaged to such extent that it must be renewed after a short period of use. The refractory materials known at present are unable to resist attacks and stresses of this kind unless the lining is protected by the application of particular conditions from direct exposure to the strong heat developed by the high purity oxygen-molten metal reactions. Accordingly, although the advantages of molten metal refining with high purity oxygen have been recognized, particularly with respect to the reduced nitrogen ballast compared to the air blown pneumatic refining processes, there remains no economical, commercially feasible process for refining of molten metal with high purity oxygen capable of providing long refractory life and high oxygen efficiency. In particular, the deficiencies of the proposed processes, emphasize the lack of a high purity oxygen refining process for molten pig iron having the aforementioned advantages to provide an economical, commercially feasible process for production of refined steel at least equal in quality to that produced by the well known basic open-hearth process from pig iron of widely varying chemical compositions.

It is accordingly one of the main objects of the present invention to provide a process for refining molten metals by surface blowing with high purity oxygen, in which, owing to the particular conditions employed, the refractory walls of the apparatus utilized in carrying out the process are

protected from undue corrosion by the excessively high temperatures developed and the chemical reactions taking place at such temperatures.

Another object of the present invention is to carry out the treatment of molten metals, and other molten materials by surface blowing with high purity oxygen in such a manner that the reactions of the oxygen gas with the constituents of the molten bath and the resulting high temperatures, to the extent possible, are limited to an oxygen jet impingement area removed from the refractory lining of the reaction vessel.

It is also a primary purpose and object of this invention to provide a process for the refining of primarily hot metal charges, that is, predominantly molten pig iron, with high purity oxygen gas in which controlled refining at substantially theoretical oxygen efficiency is accomplished.

A further object is to provide a process for refining of molten pig iron with a surface blown high purity oxygen jet in which an exceptionally high refractory life is obtained.

The invention also has as its object to provide a process of surface blowing molten pig iron with high purity oxygen in which the refining reactions and oxygen impingement on the melt surface are controlled in a manner such that over-oxidation of the molten pig iron bath is essentially avoided.

It is still another object of the invention to provide a high purity oxygen refining process which is applicable to pig iron of widely varying chemical compositions, including in particular pig iron of analyses used in ordinary basic open-hearth practice, as well as those of higher silicon and phosphorus content required for blowing in the acid Bessemer and basic Thomas converter processes to produce steels having analyses and qualities at least comparable to that of basic open-hearth steels. Another object of the invention is to provide a high purity oxygen refining process

for production of steel of excellent quality at a high rate of production, substantially comparable to Bessemer or Thomas converter practice, for example, a blowing time of from 15 to 30 minutes for charges of from 30 to 40 tons to carbon end points of 0.05% or below.

Further objects and advantages of the invention will be apparent from the following detailed description of the process and the appended drawing.

The process of the invention generally comprises refining the molten metal in a converter type or other suitable vessel with a high purity oxygen jet impinging vertically or approximately vertically on the melt surface substantially at the central portion thereof by means of a blast nozzle or other suitable jet producing means under controlled conditions, hereinafter defined, to supply to the molten metal the required amount of oxygen for completion of refining within a predetermined time, and to produce autogenous heat sufficient to insure completion of the refining and adequate temperature in the refined charge for subsequent handling.

It has been found that by suitable arrangement of the nozzle or jet producing device, and operation thereof for the supply and introduction to the molten metal of the high purity oxygen gas, suitable design of the refractory lined refining device in which the process is conducted, and proper use of amounts of materials charged, the foregoing advantages are obtained, including a very efficient protection of the refractory lining.

According to the process of the invention, the high purity oxygen jet is blown vertically, or approximately vertically upon the central portion of the surface of a bath of the molten metal, the jet having a diameter and static pressure at the point of origin, that is, at the blast nozzle or other jet producing means, and the point or origin (blast nozzle) being spaced from the bath surface, such that direct con-

tact of the oxygen jet and the molten metal is established and maintained throughout the refining period without deep penetration of the molten metal bath by the jet. In so operating, the area of jet impingement is controlled to produce a relatively confined zone of direct oxygen to molten metal contact with respect to the total surface area of the bath. It has been determined in application of the present invention to the refining of predominantly molten pig iron charges by means of high purity oxygen, that the jet blown onto the surface of the molten iron, as above described, under a relatively low static pressure at the point of origin, for example, at the overhung blast nozzle, of from 5 to 25 atmospheres (about 75 to 375 pounds per square inch), preferably at about 8 to 12 atmospheres (about 115-175 pounds per square inch), with the jet diameter at the point of origin or blast nozzle being about 1 millimeter (1/25 inch) per ton of charge, and with the point of origin or blast nozzle spaced from the bath surface from at least 150 millimeters (about 6 inches) up to about 2000 millimeters (about 80 inches), produces a sufficiently high reaction velocity of the oxygen with the bath constituents to insure the development of autogenous heat at a rate sufficient to provide the heat required for completion of the refining in a minimum of time, consistent with controlled temperature and control and development of other necessary and required process conditions, such as fluid slag, avoidance of over-oxidation (undue loss of iron to the slag), and avoidance of slopping. The process conducted under these conditions avoids a deep penetration of the oxygen gas into the molten bath which seriously impairs refractory life at the bottom of the refining vessel. In addition, the impingement area of the high purity oxygen on the central portion of the bath isolates the refractory walls of the refining vessel from the extremely high temperatures which are developed by the direct reaction of the oxygen and the molten metal.

It has also been found, according to the invention, that

the utilization of suitable design of reaction vessel and the use of the proper amount of material charged results in a ratio of the depth of the bath to the surface area of the bath which augments the protection afforded to the refractory lining of the refining vessel and is also beneficial to the progress of the refining reactions to produce finished steels of low impurity content comparable to those produced by the basic open-hearth process. In carrying out the process of high purity oxygen refining of a molten bath of pig iron, the refining vessel is of such design and the charge is of such amount that the radio of the depth of the molten bath in meters to the surface area of the molten bath in square meters should be from about 1 to 5 to about 1 to 28 in refining vessels of various design or in terms of the ratio of depth to diameter of a circular bath between 1:2.5 and 1:19. In other metallurgical processes to which the present invention is adapted substantially similar ratios may be used.

Although it is not intended to limit the present invention to any specific theory of action or mechanism, it is believed that application of the oxygen jet substantially vertically or approximately vertically upon the central portion of the bath surface brings about a flow in the molten metal from the center of the surface of the bath downwardly and then along the bottom of the refining vessel, and upwardly at the sides of the vessel to the surface of the bath, so that portions of the unrefined metal are continuously presented to a localized center of direct oxygen reaction with the bath metal, while reacted or oxidized portions of the bath move away from this reaction center. This apparent circulation of the molten material is facilitated by shaping of the bottom of the device in its refractory lining in a uniformly curved design, preferably hemispherical or similar shape, so as to offer the minimum of resistance to the circulation.

Due to the very high affinity of oxygen for iron, initial contact of the high purity oxygen jet with the molten metal bath causes a rapid combination of oxygen and iron to

form FeO in the confined central reaction zone. This is demonstrated by ignition of the oxygen and the propagation of a visible flame within the first minute of blowing. This reaction, together with oxidation of impurity elements, such as silicon and managanese, develops extremely high temperatures in the zone of direct oxygen contact with the molten metal which approach the boiling point of iron, as demonstrated by the evolution of a fume containing iron oxide and managanese oxide. A portion of the iron oxide goes to the slag with the other oxidized elements and a portion diffuses into the bath under the influence of the bath circulation, so that within the first three minutes of the blowing vigorous carbon combustion is initiated due to the high temperatures developed by these reactions. The ensuing reaction of carbon with the FeO and directly with the oxygen gas in the confined direct oxidation zone causes rapid formation of carbon monoxide and the formation of this CO causes a strong boil or agitation of the bath, which augments the bath circulation to continuously present unrefined metal to the oxygen gas reaction zone and to create a slag-metal emulsion. The oxygen jet thus contacts the emulsion of bath and slag components which presents a larger reaction surface and causes the refining reactions to progress rapidly although the oxygen jet does not penetrate deeply into the molten metal bath and is confined to an impingement area at the central portion of the bath surface. This vigorous boiling action is opposed by the pressure of the oxygen jet only in the area of impingement, and outside of this area it represents primarily endothermic reduction of FeO by carbon to form the evolved carbon monoxide, which reaction thus effectively encompasses the zone of direct oxygen reaction at which the highest temperatures prevail affording a maximum measure of protection to the refractory lining of the refining vessel.

In conducting the process in the manner set forth above, the advantage of exceptionally high refractory life is obtained. For example, in refining of pig iron having the

following chemical composition: carbon 3.8-4.2, silicon 0.6-1.3, managanese 1.4-2.2, phosphorus 0.120-0.250, and sulfur 0.045 max., and a slag having the following composition SiO_2 12-17%, CaO 38-44%, MgO 5-10%, MnO 9-13%, P_2O_5 1.2-1.8%, and Fe 12-17%, in a 30 ton converter, the average durability of the refractory is over 200 heats (foregoing in percentages by weight). By comparison, in basic Bessemer practice utilizing air rather than high purity oxygen, the removable converter bottom must be relined after only 35 to 60 heats. In addition, the refractory life obtainable by the process of the invention surpasses that obtained in normally operated open-hearth practice in that in refining of a normal charge by basic open-hearth about 36 lbs. of refractory brick is consumed per ton of steel produced to which must be added some 40 pounds of sintered dolomite for fettling operations, whereas total refractory consumption in the instant process is only about 24 lbs. per ton of steel produced. This advantage is even greater when compared to oxygen lancing in an open-hearth which accelerates refractory consumption.

The further advantage of high oxygen efficiency is obtainable according to the process of the invention when the oxygen jet impinges on the central portion of the molten bath surface from directly above, that is, approximately vertically. Oxygen efficiencies calculated on the basis of total oxygen input compared to oxygen consumed in the bath reactions is approximately 95%. This is demonstrated by an average oxygen consumption of only 57 normal cubic meters (measured at standard conditions of temperature and pressure) per ton of steel including oxygen consumption for heating the converters after relining. This compared with calculated or theoretical oxygen requirements for the refining of the various pig irons blown to steel analyses set forth below represents about a 95% efficient utilization of oxygen. In addition, analyses of waste gases effluent from the converter indicate that the carbon in the instant process burns almost 100% to carbon monoxide,

the analyses showing on the average over 90% CO and less than 10% CO_2, indicating that the oxygen input is not lost by burning with the carbon monoxide above the melt within the refining vessel, as in the case of low angle impingement from tuyeres positioned in the side walls of the refining vessel. Moreover, this is a distinct advantage in the instant process, since the reaction of the oxygen with the melt provides more than sufficient heat for the refining, and additional heat by burning of the carbon monoxide to carbon dioxide above the melt is to be avoided. The potential heat units in the effluent carbon monoxide may be utilized in various ways by subsequent burning.

As above mentioned, it is a characteristic of the process of the invention that in the confined zone of direct oxygen reaction at the surface of the molten metal bath, the oxidation products of the impurities in the pig iron, such as silicon and managanese, as well as the oxidized iron form an early fluid slag which is always very rich in oxides, that is, highly oxidizing. With the formation of the slag-metal emulsion, the iron oxide reacts with the carbon present in the bath, primarily outside of the direct oxygen-metal reaction zone, and since such slag-metal reactions are endothermic, the molten bath is maintained cooler in the vicinity of the walls of the refining vessel or converter. For example in the formation of one kg. of FeO, by direct oxidation with the oxygen jet and absorbed as iron silicate into the slag, 80 kg. calories of heat are developed. An equal amount of heat is absorbed outside of the confined central zone of direct oxidation as the FeO (as silicate) is reduced by the carbon in the bath, as one example of slag metal reactions occurring during the blowing.

This formation of an early highly oxidizing fluid slag is of particular value in basic refining when the process is applied to pig iron of analyses used in ordinary open-hearth practice, which would not be amenable to refining by either the acid Bessemer process due to the phorphorus content, or the basic Thomas process due to the lack of sufficient

phosphorus. With the rapid heating of the slag cover and metal bath, the proper amounts of lime or lime supplying substance, such as limestone, may be added at the beginning of the blow and during the blow to insure formation and maintenance of a slag of sufficient basicity. Thus, the early fluid, basic and highly oxidizing slag formed provides an accelerated rate of phosphorus and sulfur removal from the bath, leaving the finished steel very low in both elements. With normal open-hearth pig irons having phosphorus contents ranging from about 0.1-0.35%, and even higher, e. g., 0.85% P, and with correct lime additions, final phosphorus contents not higher than about 0.025% and as low as 0.010% are obtained by the time the carbon end point is reached with only a single slagging operation. With sulfur contents in the pig iron of from 0.045 to 0.08%, the sulfur is decreased to 0.02-0.025%, and on the lower range of sulfur in the pig iron to values as low as 0.012%. In usual operations, from 1 to about 4.5% lime is charged to obtain the foregoing result, depending upon the phosphorus content in the pig iron. In addition, all of the lime requirement may be added during initial charging before blowing is started, particularly where the silicon content of the pig iron, which is one of the first oxidized elements, is sufficiently high. On the other hand, the lime may be charged in increments during the blow, but with a sufficient amount initially charged to provide a basicity adequate to absorb the phosphorus.

In the normal range of phosphorus in pig iron of basic open-hearth quality from about 0.1 to 0.35%, the required slag volume including the lime charge is advantageously much lower than the slag volume in the bottom blown basic Thomas process. The iron content of the slag varies from about 9 to 18%, with generally higher FeO content in the slag at higher phosphorus contents in the pig iron, and also at lower managanese contents. Accordingly, the lower percentage of slag, for example, 11 to 12% compared to about 22% in the Thomas process results in comparable or lower total iron content lost to the slag, even though the FeO

content of the slag may be higher than the usual 10% in the basic Thomas process.

The process in its preferred embodiment utilizes high purity oxygen, by which the term is meant oxygen gas analyzing at least 97% O_2. For minimum nitrogen content in the finished steel of at least 98% oxygen and preferably 99% or higher should be utilized. The frequency curves based on produced steel analyses indicate that oxygen of at least 98% purity provides a peak or maximum at a nitrogen content of from 0.002 to 0.003%, with 95% of all heats blown showing a nitrogen content of 0.004% or less.

The vigorous boil, above mentioned, continues up to the carbon end point, and together with the induced circulation of the bath metal toward and away from the central zone of direct oxygen reaction, effectively counteracts any tendency to overoxidation of the bath. When the flame dies and carbon combustion is completed, the bath becomes relatively quiet and intimate contact between slag and metal bath ceases. The turbulence of the bath and slag due to the oxygen stream impinging from directly above is insufficient to cause continuance of oxygen-metal reactions. As a result, steels blown by the process of the invention do not suffer from the deteriorating effects of high oxygen (FeO) contents. Direct oxygen determination by the hot extraction method yielded oxygen contents of 0.04% maximum for heats that were blown to a carbon end point of from 0.05 to 0.10% C. Thus, the oxygen content of steels produced by the high purity oxygen blowing process compare very favorably with oxygen contents of basic open-hearth steel in the same carbon range, and are definitely lower in oxygen content than bottom blown Bessemer steels using air, oxygen enriched air, oxygen and steam, or other gas mixture.

As in the basic Bessemer process, the silicon is rapidly eliminated. However, in contrast to the basic Bessemer process, the use of high silicon charges presents no problem due to the fact that slopping is not encountered in the process of the invention to any degree similar to that in the bottom blown Bessemer practice. In fact, higher silicon pig irons actually are advantageous in the high purity oxygen blowing due to the heat producing effect of this element in the early stages of the blow with the result that higher scrap charges can be made in the process.

Regarding scrap additions, the process advantageously may utilize scrap charges of up to about 30%, depending primarily upon the silicon content of the pig iron, and also on the temperature of the hot metal charge. For lower ranges of silicon, such as 0.3 to 0.7% scrap charges of from 10 to 15% are permissible. With silicon in amounts from 1 to 1.2%, scrap charges of 20 to 25% may be utilized.

In general, the managanese content of the fully blown metal and of the slag increases with the total manganese content (pig iron and scrap). However, it is a characteristic of this oxygen steel making process that the high temperatures developed in the reaction zone between the bath metal and the slag cause a rereduction of manganese from the slag into the bath during the latter portion of the refining period. In the last minutes of the blow, the manganese content in the bath again decreases as the carbon drops to its final value, that is, at a normal end point of 0.04-0.06. Accordingly, the manganese content in the finished steel and in the slag is subject to some control, and is governed by slag composition and volume, temperature and final carbon content. With the use of a minimum amount of slag rich in iron oxide, for example only 70 kg. per ton of steel, the amount of loss of managanese to the slag by burning may be considerably reduced. As above mentioned, extensive tests have shown that the amount of slag can be kept considerably lower than the conventional pneumatic process, such as the Bessemer and Thomas processes. Under these conditions of high developed temperature in the refining process and low slag volume with high iron oxide content,

a finished steel containing managanese in quantities at least 10 times the amount of carbon, for example, 0.6 to 0.8 Mn at carbon end points of 0.05% are obtainable. Accordingly, it is possible to pour rimming steels down to relatively very low carbon contents without any addition of managanese and deoxidizing agents. Under actual operating conditions the best practice for production of standard grades is to refine down to 0.06-0.08% C and to recarburize in the ladle. This practice results in a manganese content of from 0.6 to 0.8 and eliminates the necessity for manganese additions to conform with the usual analysis specifications. The above manganese content easily compares with the conventional composition of rimming low-carbon open-hearth steels, in fact such analyses are near the upper limit of the range. It is also possible to catch the heat at higher carbon contents, so that the resulting content in manganese will be of a higher order than is normally encountered in rimming open-hearth steels of identical carbon content. Thus, it is possible to produce rimming low carbon high purity oxygen blown steels of a predetermined strength which is based on an inherently higher manganese content of the heat.

It has also been found that a steel containing 0.1% carbon and as high as 1.5% manganese may be obtained, for example by the addition of ordinary blast furnace ferromanganese, e. g., 15 kg. of 48% blast furnace ferromanganese per ton suffices, and results in an increase of about 0.05% in the carbon content. In normal steel making operations it was not previously possible to obtain such steels without the use of expensive refined ferromanganese products. Steels of such analyses, not only exhibit increased toughness and yield strength but other properties, such as pressure weldability, are improved.

To exemplify the high manganese recovery in the steel without ferromanganese additions after the blow, the results of the following heats are provided. As indicated above, since the managanese content, under otherwise equal

conditions, increases in the finished steel with increase in pig iron, it is to be noted that particularly high manganese content pig irons were employed. Nevertheless, it is evident that due to the extremely high temperatures developed in this high purity oxygen process, a manganese recovery is possible which cannot be reproduced in known processes.

Heat No. 1.—Pig iron analysis: 4.16% C, 3.02% Mn, 0.14% Si, 0.074% P, 0.040% S. Last converter control test (without ferromanganese or deoxidizers): 0.09% C, 0.96% Mn, 0.005% Si, 0.039% P, 0.013% S, 0.007% N_2.

Heat No. 2.—Composition of pig iron: 4.30% C, 3.24% Mn, 0.33% Si, 0.072% P, 0.034% S. Last converter control test (without ferromanganese or deoxidizer): 0.08% C, 1.02% Mn, 0.005% Si, 0.037% P, 0.010% S, 0.004% N_2.

Heat No. 3.—Composition of pig iron: 4.21% C, 2.88% Mn, 0.27% Si, 0.076% P, 0.044% S. Last converter control test (without ferromanganese or deoxidizer): 0.07% C, 0.93% Mn, 0.005% Si, 0.037% P, 0.012% S, 0.004% N_2.

From the foregoing test, it may be seen that manganese recovery at least 10 times as high as the final carbon content in the finished steel is obtainable by the process of the invention utilizing pig iron having manganese on the order of 3%.

In regard to output, the combustion of the impurities of the pig iron and the iron content of the slag total a loss of about 8.0% with an additional 0.8% of iron lost in the dust fume from the process. With mechanical losses averaging about 0.8%, the percentage recovery of the refining process is approximately 90%, comparable to the yield obtainable by the basic open-hearth process. In the progress of the high purity oxygen blowing, up to about the eighth minute, oxidation of the iron progresses under formation of comparatively large amounts of FeO, which, as above stated, promotes a desirable quick liquefaction of the basic lime slag. At this stage in the blow, the slag shows maximum

values of from 25-30% FeO. In the further course of the process reduction of Fe from the slag occurs which continues until the carbon content of the bath of about 0.07% is reached. The FeO in the slag decreases to about 10-12%. On further removal of carbon, the FeO in the slag again increases so that in the final slag generally an iron content averaging 14% is obtained, and only at very low carbon heats does the iron content exceed this value.

Under these known metallurgical conditions above set forth, the total oxygen requirement is calculated on the basis of oxygen pick-up of the heat during the refining period. Summation of these oxygen gas volumes required for the oxidation to complete refining indicates substantially a straight line function on oxygen input, and corresponding to this relative constancy of oxygen input, the oxygen pick-up proceeds uniformly during the blow. The oxygen input is maintained at a rate such that the speed of the refining process insures satisfactory rereduction of FeO from the slag, in the manner set forth above. In actual practice, based on experience in operation of 30 ton converters, oxygen feed rates may be maintained such that depending upon pig iron analysis, amount of scrap addition and desired finished steel analysis, the refining to usual carbon end points on the order of 0.05% C is completed in from about 15 to about 30 minutes, preferably 18 to 22 minutes. Flow rates of from about 4000 to 8000 cubic meters of oxygen per hour are representative of the oxygen input under these conditions.

In such exemplary commercial practice with 30 ton converters charged to 35 to 36 tons, oxygen pressures at the blast nozzle of about 8 to 10 atmospheres and oxygen jet or blast nozzle diameters of from about 27.5 to 35 millimeters (1.1 to 1.4 inches) with nozzle spacings varying from 25 to 50 inches (about 650 to 1250 millimeters have been used, the preferred spacing being from 30 to 40 inches (about 750 to 1000 millimeters). In general, it may be stated

that as the oxygen pressure and nozzle diameter are increased, the nozzle spacing is also increased, for example, as the capacity of the refining vessel and total charge is increased. Under these conditions, deep penetration of the molten metal bath is avoided, while the necessary displacement of the slag cover to maintain direct oxygen to molten metal contact is insured. However, in the unusual circumstances of an abnormally stiff slag cover, the blow may be initiated using mechanical means for penetrating the slag cover to establish oxygen to metal contact.

It is to be noted, that in certain instances particularly where the rate of oxygen input is relatively high, that is, the total blowing time is in the lower portion of the range above stated, the pressure of the oxygen jet at the blast nozzle may be reduced in the last few minutes of the blow to reduce the rate of oxygen input, which is beneficial in supporting the inherent characteristic of the process in regard to avoidance of over-oxidation of the heat. Due to this characteristic of the process, it is generally unnecessary to utilize any deoxidizing agents such as ferromanganese and ferrosilicon in the production of semi-killed steels, and only in the production of killed steels are the conventional deoxidizers employed.

The process has as one of its major advantages the applicability to pig iron of analyses used in ordinary open-hearth practice, which would not be amenable to refining by either the acid Bessemer process or the basic Thomas process. In addition, the process is fully applicable to pig irons having analyses of the type which are normally utilized in either the acid Bessemer or basic Thomas processes. Typical illustrations of the following pig irons and the finished steels produced therefrom indicate that the process produces steels comparable to open-hearth quality from pig irons of widely varying phosphorus and silicon contents.

(1) 4.0% C, 1.5-2.0% Mn, 0.7-1.2% Si, 0.1-0.24% P, 0.05% S, and 0.01% N blown to a finished steel of the following

analysis: 0.06% C, 0.35% Mn, 0.00% Si, 0.026% P, 0.025% S, and 0.0025-0.0035% N (oxygen about 98%).

(2) Pig iron analyzing 3.6-4.25% C, 1.4-3.2% Mn, up to 0.3% Si, 0.06-0.1% P, 0.04-0.07% S, and 0.01% N from which steel of the following analysis is obtained: 0.06% C, 0.35% Mn, 0.00% Si, 0.01-0.02% P, 0.022% S, and 0.001-0.002% N.

(3) Illustrative of a grade of pig iron falling between that of normal open-hearth analysis and basic Bessemer pig iron is the following: 3.61% C, 2.16% Mn, 0.46% Si, 0.856% P, 0.062% S. Blowing of such a charge of rather unfavorable chemistry by the process of the invention yielded a steel of the following composition: 0.04% C, 0.15% Mn, 0.0% Si, 0.014% P, 0.045% S. Clearly, such a pig iron would be definitely unsuitable for basic Bessemer (Thomas) process refining, and would also present considerable difficulty if used for open-hearth refining.

The accompanying drawing diagrammatically illustrates a device for carrying out the present invention. In this drawing, reference numeral 1 denotes a metallic wall and 2 the refractory lining of the refining vessel. An oxygen supply lance 3 is centrally positioned and overhung above the charge and is provided with a nozzle 3' for the introduction of the oxygen gas, inserted in an opening of the cover 4. The material charge, including molten pig iron, melted scrap, and slag forming additions, such as limestone, is indicated at 5 and the depth and diameter of the upper surface of the molten bath in the quiescent state are denoted by H and D, respectively. The lance 3 is retractable, and is provided with water cooling ducts and connections (not shown). The cooling water in actual practice is supplied to the lance at a pressure of from 4 to 6 atmospheres and the normal flow rate is about 36 to 40 cubic meters per hour. Under such conditions the temperature of the cooling water increases from approximately 14° centigrade input to a maximum of about 30° centigrade in the effluent from the lance.

In the preferred commercial practice of the invention, a converter shaped vessel with an open mouth is usually provided, through which the lance is inserted into and retracted from operating position, as indicated in the example set forth below. In this manner, suitable gas take off devices may be positioned at the throat of the converter type vessel to collect the off gases and separate the particulate fume therefrom.

The following is a detailed description of a typical operation of the process, which is not to be regarded as a limitation on the invention, but rather as a complete specific embodiment thereof.

Example 1

A closed bottom converter of normally 30 tons (metric) capacity is charged with a total of about 36 tons of metal through an open mouth. The oxygen lance is inserted through the mouth of the converter to the adjusted distance above the melt surface. The diameter of the surface of the bath with such a charge is about 5 meters and the depth of the bath about 1 meter. A typical cycle of operations is given below on a time table basis.

	Hours
7100 kg. plant return scrap charged to converter	0
29,600 kg. pig iron poured from mixer into converter having an analysis as follows: 4.04% C, 0.99% Si, 1.73% Mn, 0.153% P, and 0.045% S	0.08
Addition of 850 kg. limestone and 60 kg. bauxite	0.10-0.13
Introduction of nozzle, oxygen jet initiated at a nozzle pressure of 10 atmospheres (147 p. s. i.) with a nozzle spacing above the bath of 100 millimeters	0.15
850 kg. limestone and 200 kg. rolling mill iron slag added	0.16
750 kg. limestone chips added in five parts of 150 kg. each	0.22-0.28

Oxygen pressure reduced to 8 atmospheres	0.30
Mouth flame transparent, nozzle withdrawn, oxygen supply turned off—end of blowing time at 19 minutes	0.34
Converter contents sampled and analyzed as follows: 0.05% C, 0.00% Si, 0.31% Mn, 0.024% P, 0.02% S	0.35
Slag drawn off	0.35-0.39
150 kg. Spigel iron added to contents of converter	0.39
Slag remaining in converter stiffened with 30 shovelfuls of limestone	0.39-0.42
Steel poured into pan, temperature measured at 1575° C., 6 kg. electroflour added to pan	0.42-0.45

Final test analysis on pouring into ingot mold was: 0.07% C, 0.32% Mn, 0.022% P, 0.020% S, 0.0035% N. Oxygen consumption 1950 cubic meters. This oxygen consumption is about 54 cubic meters (measured at standard conditions) per ton and compares with a theoretical oxygen requirement of 51 cubic meters (measured at standard conditions), and therefore indicates an oxygen efficiency of 95%.

The process of the present invention may be also applied to the production of metals, for example, production of steel, from solid starting materials. In the production of steel, pig iron and scrap iron, and if desired certain alloys and fuels, such as coal or wood, are introduced into the refining vessel. As materials for producing heat for melting, coke, ferrosilicon, calcium carbide, aluminum alloys and the like, which are converted into slag or gaseous products at the prevailing refining temperatures can be added. The total amount of the starting material mixture may be introduced as a single charge prior to initiation of the melting, or may be gradually fed in small incremental amounts. Sufficient fuel should be present for producing the combustion necessary to provide the heat of fusion of the solid charge. After ignition of the fuel, melting of the initial mixture is brought about by the action of the oxygen jet.

The melting procedure is started by means of an ignited body which is introduced immediately prior to the initiation of blowing of the oxygen jet, and is preferably positioned at that portion of the solid charge where the oxygen jet comes in direct contact therewith.

Thus, according to the present invention, a steel may be produced with a minimum consumption of fuel, for foundries or rolling mills, by melting the iron to be converted into steel with low grade fuel and a high purity oxygen jet blast, for example, in cupola furnace, or in a converter type vessel itself, and subjecting the thus melted solid charge to high purity oxygen refining in the above described manner in a suitable refining vessel, such as a converter. In carrying out such melting and refining treatment with high purity oxygen, the energy consumption is extremely low, amounting to only 100 cubic meters of oxygen (measured at standard conditions) per ton of steel produced. Of course, as indicated above in the refining of primarily hot metal charges constituting pig iron with analyses as set forth above to refine steels of 0.05% carbon content and analyzing as above indicated, the average oxygen consumption is only about 57 cubic meters per ton (measured at standard conditions).

The present process of surface blowing with high purity oxygen is also applicable to the desulfurization of coprous materials and to the production of glass in the converter with the use of sodium chloride. Furthermore, the process is applicable to the treatment of blast furnace slag to the elimination of sulfur and conversion of slags into melted cement or glass-like materials of the type used for the manufacture of slag wool.

This application is a continuation-in-part of my copending application Serial No. 206,147, filed January 16, 1951,

now abandoned. It will be understood that the present invention is not limited to the specific materials, steps and other specific details described above and may be carried out with various modifications without departing from the scope of the invention as defined in the appended claims.

CLAIMS

We claim:

1. Method of refining molten impure iron in the presence of a slag in a vessel having a refractory lining by blowing with oxygen, which comprises discharging a stream of oxygen vertically downwardly through the slag layer onto and below the surface of the bath at the central portion thereof, to an extent to avoid material agitation of the bath by the oxygen stream, the contact of the oxygen with the bath resulting in reaction of the oxygen with a portion of the iron and with the oxidizable impurities of the bath in a localized reaction zone spaced a substantial distance from the refractory lining, the reactions in said zone resulting in refining of the iron and gas evolution and in the production of high temperature in the reaction zone away from the refractory lining, said reaction producing a circulatory movement in the molten metal, which circulatory movement brings those portions of the molten metal bath which are remote from the reaction zone into the reaction zone whereby those portions are subjected to said reaction with minimum injury to the refractory lining.

2. The gaseous oxygen process set forth in claim 1 in which the oxygen is blown into said vessel under pressure in a range between about five and about twenty-five atmospheres above normal atmospheric pressure.